



Roanoke County Design Handbook

Adopted May 26, 2009

Amended March 22, 2011

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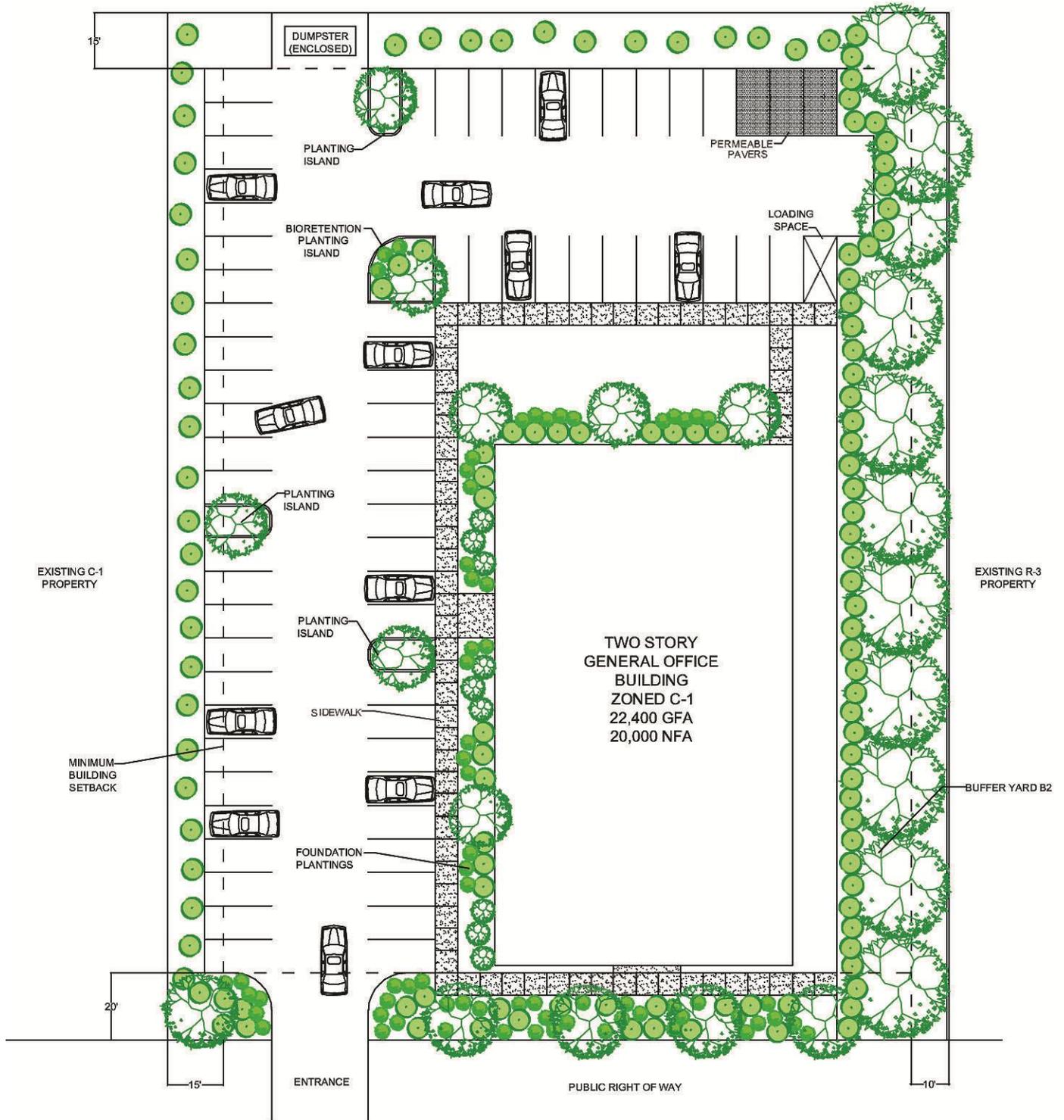
ELEMENT	PAGE
Chapter 1: Site Design	
Section 1.1 Site Layout Example	1-1
Chapter 2: Landscaping	
Section 2.1 Screening Materials	2-1
2.2 Landscaped Buffer Yards	2-3
2.3 Right-of-Way Planting Strips	2-8
2.4 Landscaped Medians within Parking Areas	2-10
2.5 Recommended Native/Naturalized Plant List	2-11
2.6 Highly Invasive Species List	2-16
2.7 Native Plant Guide for Stormwater Management Areas	2-17
Chapter 3: Transportation	
Section 3.1 Parking Area Design	3-1
3.2 Typical Paving	3-5
3.3 Permeable Paving	3-5
3.4 Sidewalks	3-9
3.5 Shared Use Paths	3-10
3.6 Trails	3-12
3.7 Bicycle Accommodations	3-15
3.8 Private Roads	3-16
Appendices:	
A Board of Supervisors Ordinances	A-1
B Sidewalk, Shared Use Path and Private Road Standards References	B-1

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Chapter 1: Site Design

Section 1.1 – Site Layout

Figure 1.1-1 Site Layout Example



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Chapter 2: Landscaping

Section 2.1 – Screening Materials

Figure 2.1-1 Stockade Fence

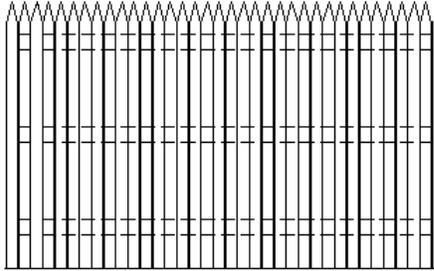


Figure 2.1-2 Decorative Masonry Wall



Figure 2.1-3 Brick Wall

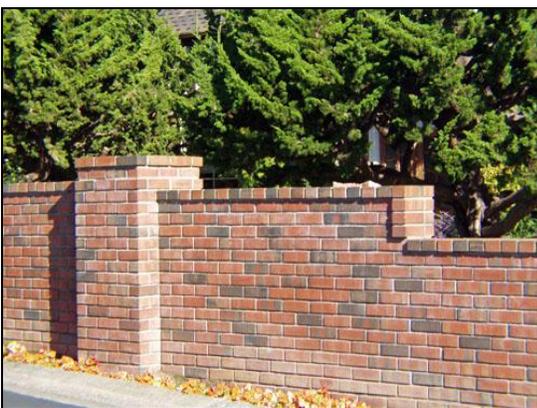


Figure 2.1-4 Three (3) Foot Tall Earth Berm

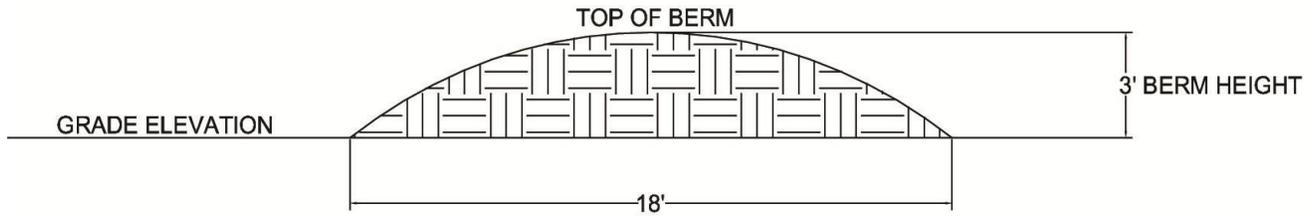


Figure 2.1-5 Six (6) Foot Tall Earth Berm

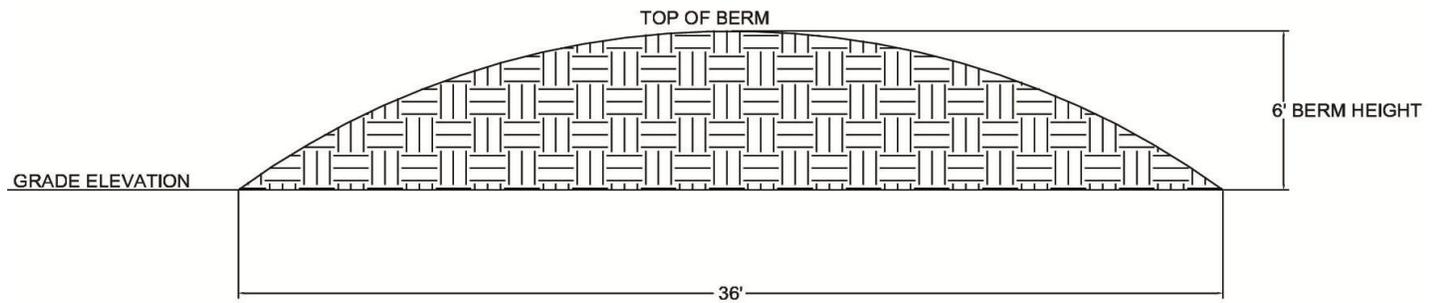
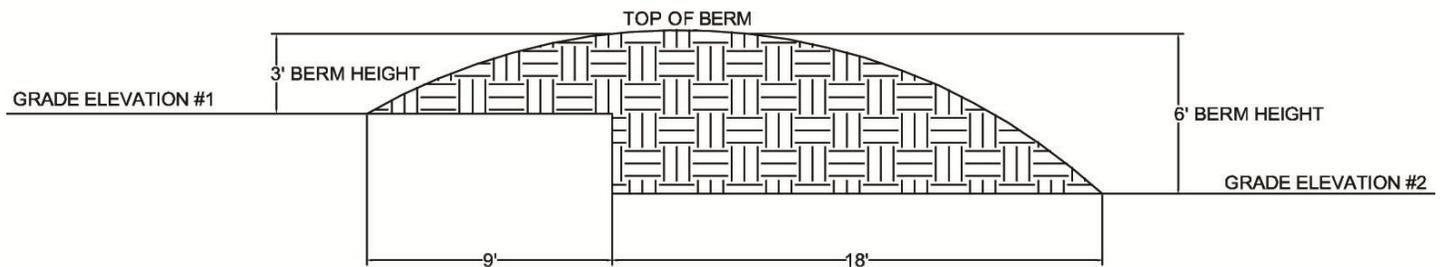


Figure 2.1-6 Varying Height Earth Berm spanning two different grade elevations



Section 2.2 – Landscaped Buffer Yards

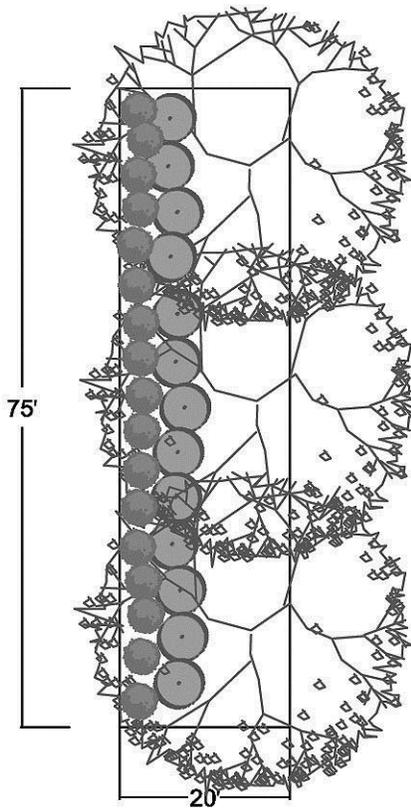
Figure 2.2-1 Type A Buffer

“Row” should not be construed as meaning that the plants must be uniformly planted.

TYPE A BUFFER

OPTION 1:
20' Buffer

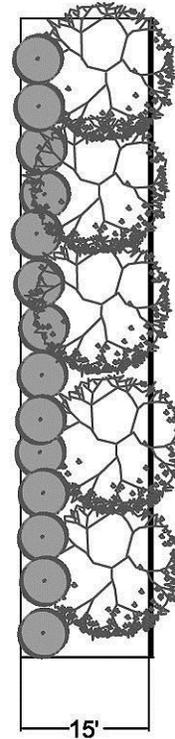
For every 75' consisting of:
One row of large deciduous trees (3)
One row of large evergreen shrubs (12-14)
One row of large deciduous shrubs (16-18)



OPTION 2:
15' Buffer

For every 75' consisting of:
One row of small deciduous trees (5)
One row of large evergreen shrubs (12-14)
6' Screening

PLAN VIEW



ELEVATION

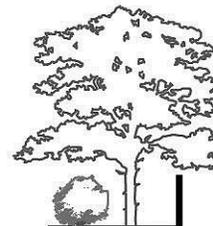
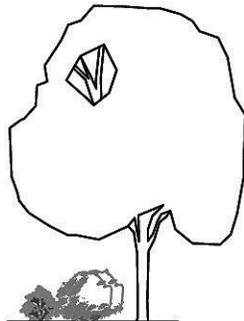


Figure 2.2-2 Type B Buffer

“Row” should not be construed as meaning that the plants must be uniformly planted.

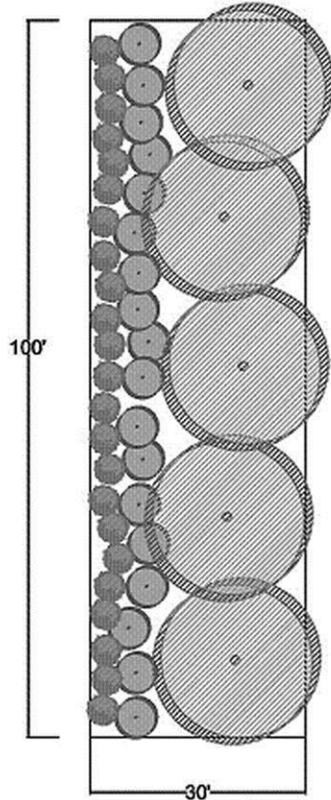
TYPE B BUFFER

OPTION 1:
30' Buffer

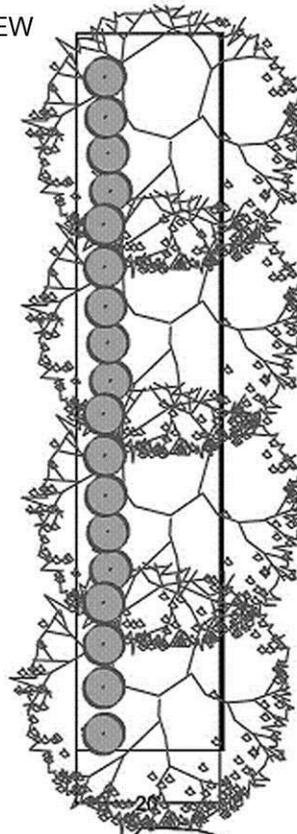
For every 100' consisting of:
One row of large evergreens trees (5)
One row of large evergreen shrubs (16-18)
One row of large deciduous shrubs (22-24)

OPTION 2:
20' Buffer

For every 100' consisting of:
One row of large deciduous trees (4)
One row of large evergreen shrubs (16-18)
6' Screening



PLAN VIEW



ELEVATION



Figure 2.2-3 Type C Buffer

“Row” should not be construed as meaning that the plants must be uniformly planted.

TYPE C BUFFER

OPTION 1:
40' Buffer

- For every 100' consisting of:
- One row of large evergreens trees (5)
- One row of small deciduous trees (6)
- One row of large evergreen shrubs (16-18)
- One row of large deciduous shrubs (22-24)

OPTION 2:
30' Buffer

- For every 100' consisting of:
- One row of large deciduous trees (3)
- One row of large evergreen shrubs (16-18)
- One row of large deciduous shrubs (22-24)
- 6' Screening

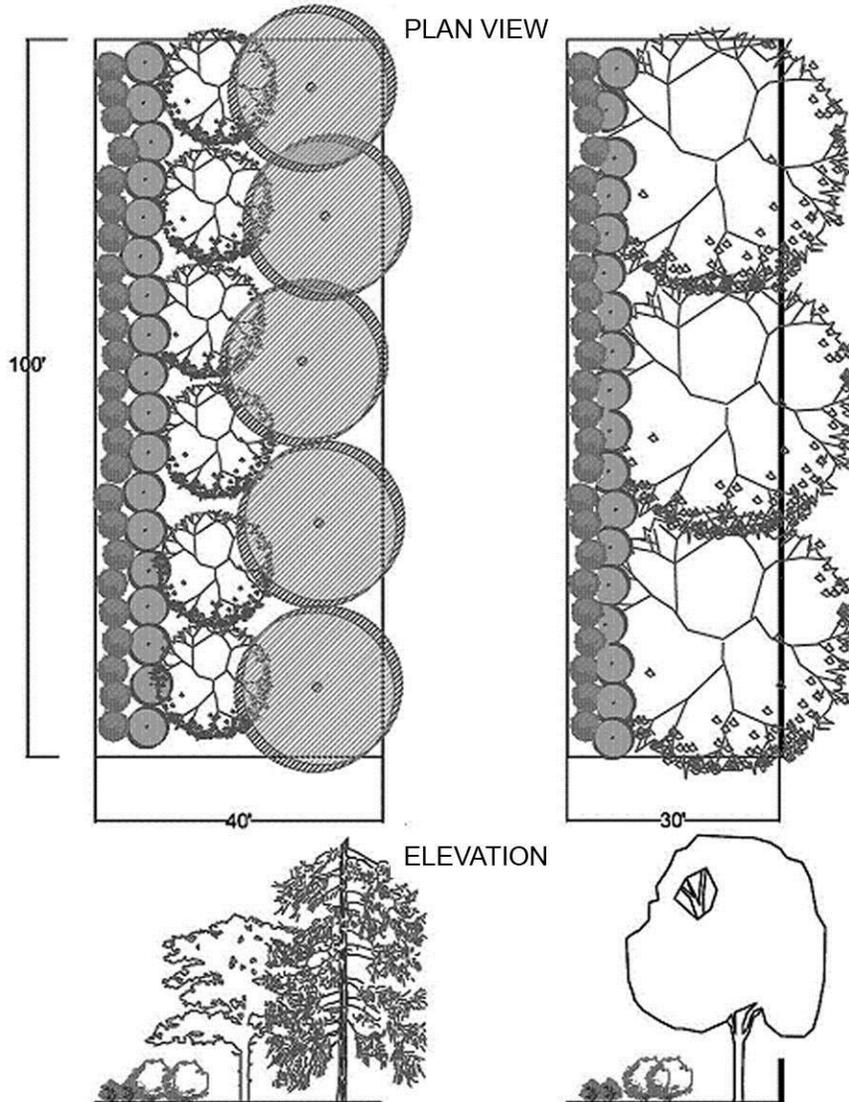


Figure 2.2-4 Type D Buffer

“Row” should not be construed as meaning that the plants must be uniformly planted.

TYPE D BUFFER

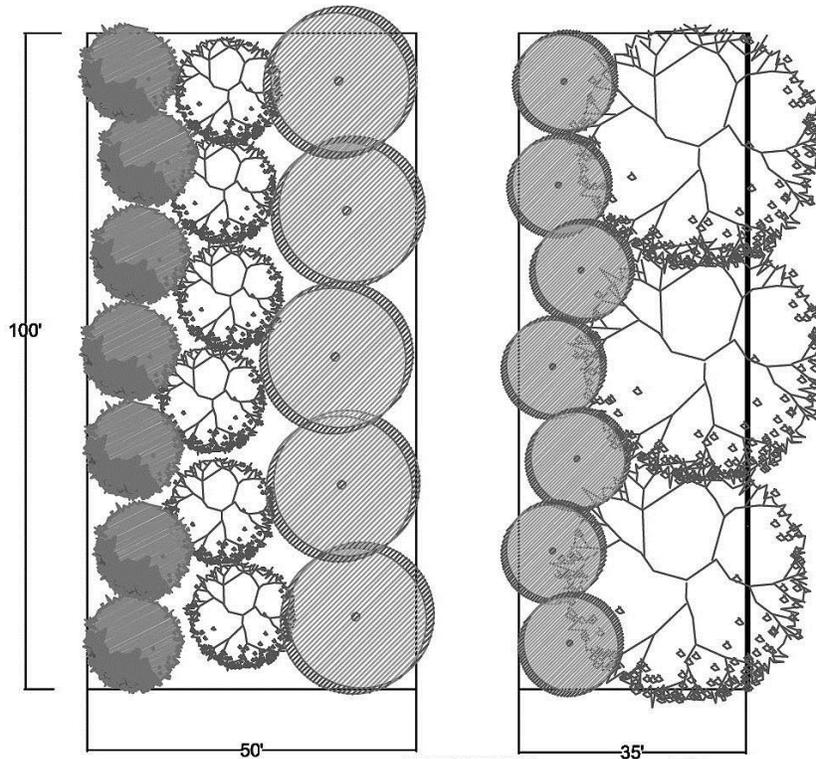
OPTION 1:
50' Buffer

For every 100' consisting of:
One row of large evergreen trees (5)
Two rows of small deciduous trees, two
different species (6-7 per row)

OPTION 2:
35' Buffer

For every 100' consisting of:
One row of large deciduous trees (3)
One row of small evergreen trees (6-7)
6' Screening

PLAN VIEW



ELEVATION

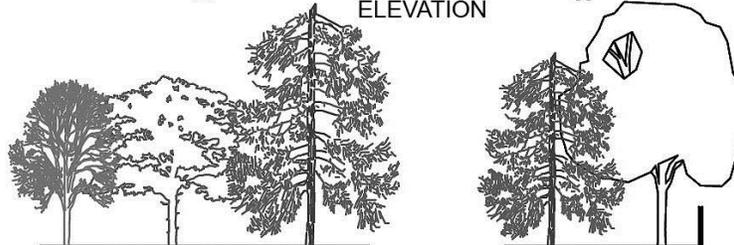


Figure 2.2-5 Type E Buffer

“Row” should not be construed as meaning that the plants must be uniformly planted.

TYPE E BUFFER

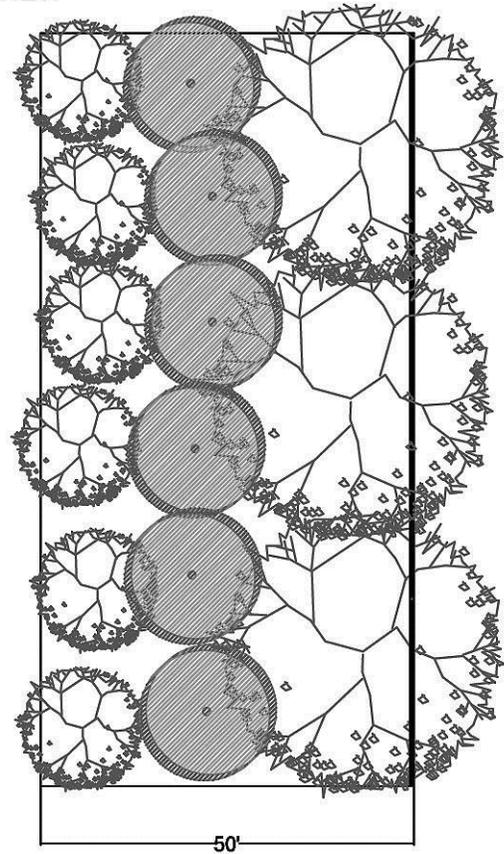
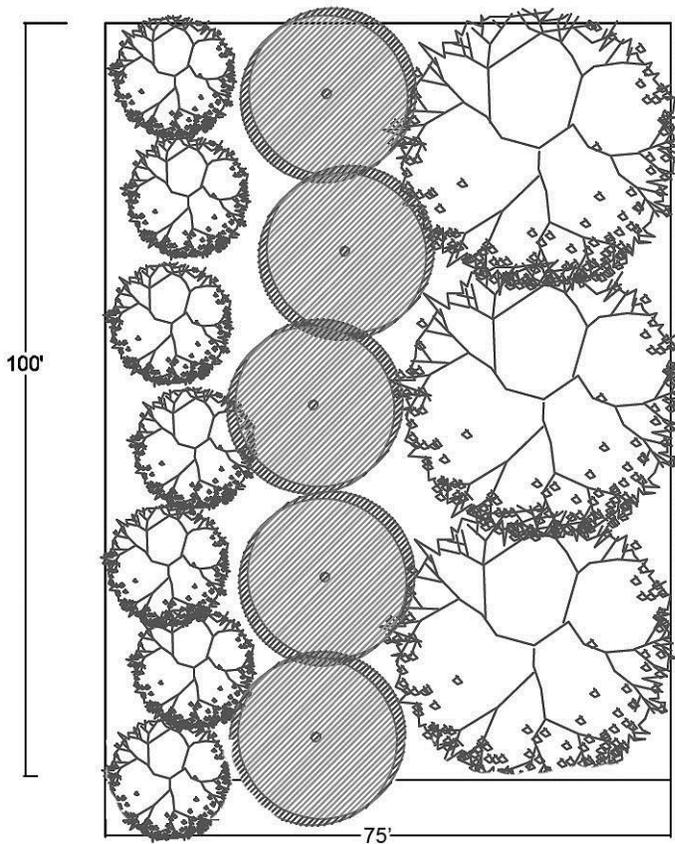
**OPTION 1:
75' Buffer**

- For every 100' consisting of:
One row of large deciduous trees (3)
One row of large evergreen trees (5)
One row of small deciduous trees (7)

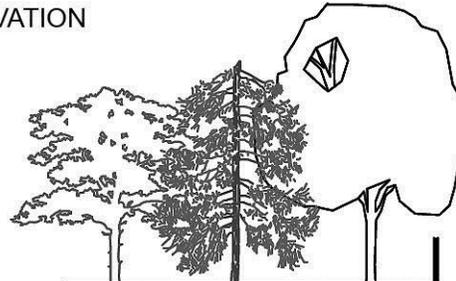
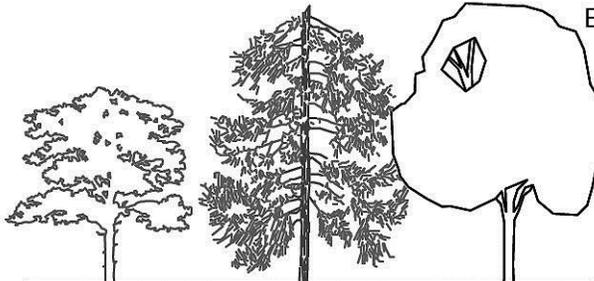
**OPTION 2:
50' Buffer**

- For every 100' consisting of:
One row of large deciduous trees (3)
One row of small evergreen trees (6)
One row of small deciduous trees (6-7)
6' Screening

PLAN VIEW



ELEVATION



Section 2.3 – Right-of-Way Planting Strips

Figure 2.3-1 Typical Planting Strip

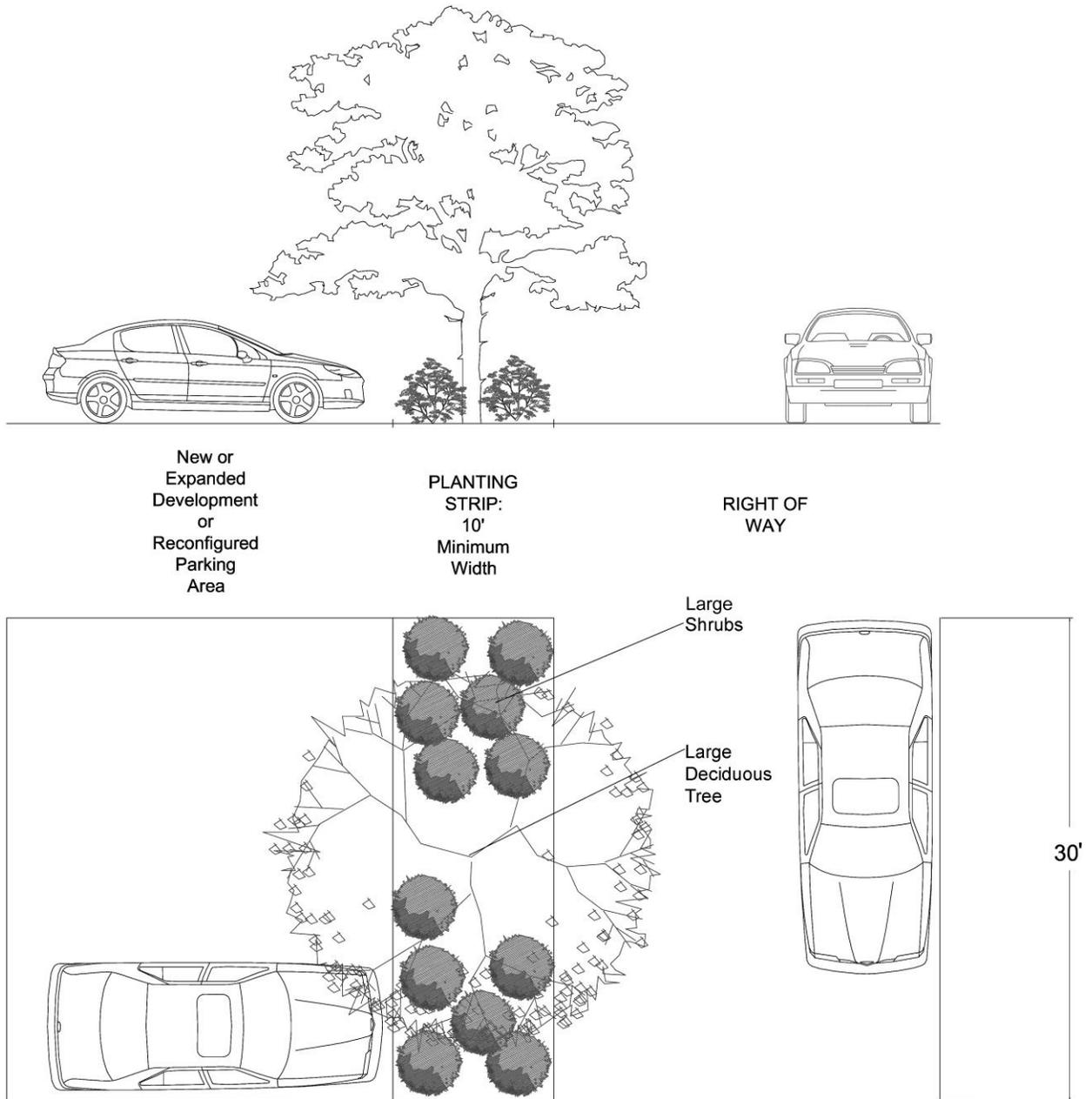
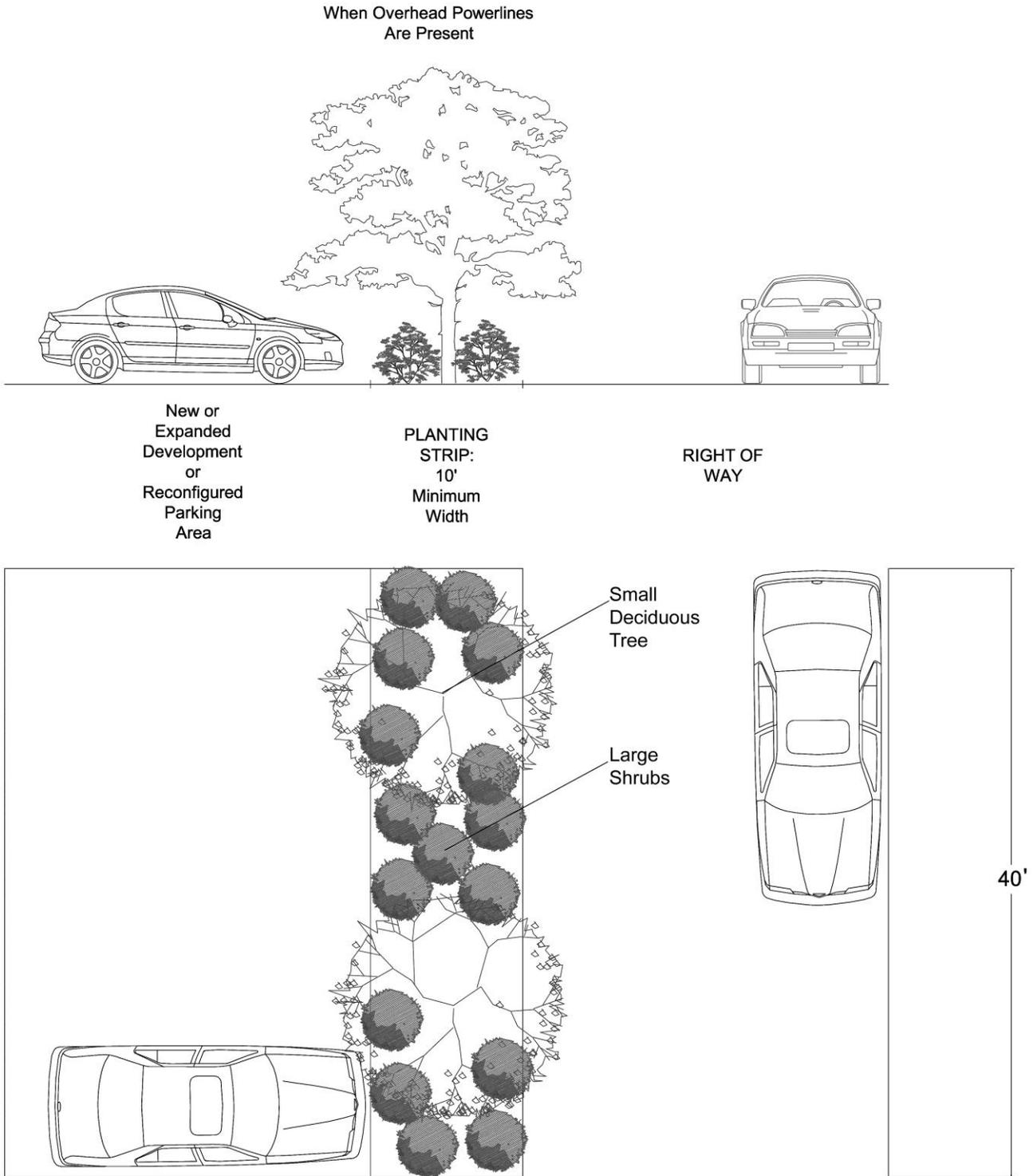
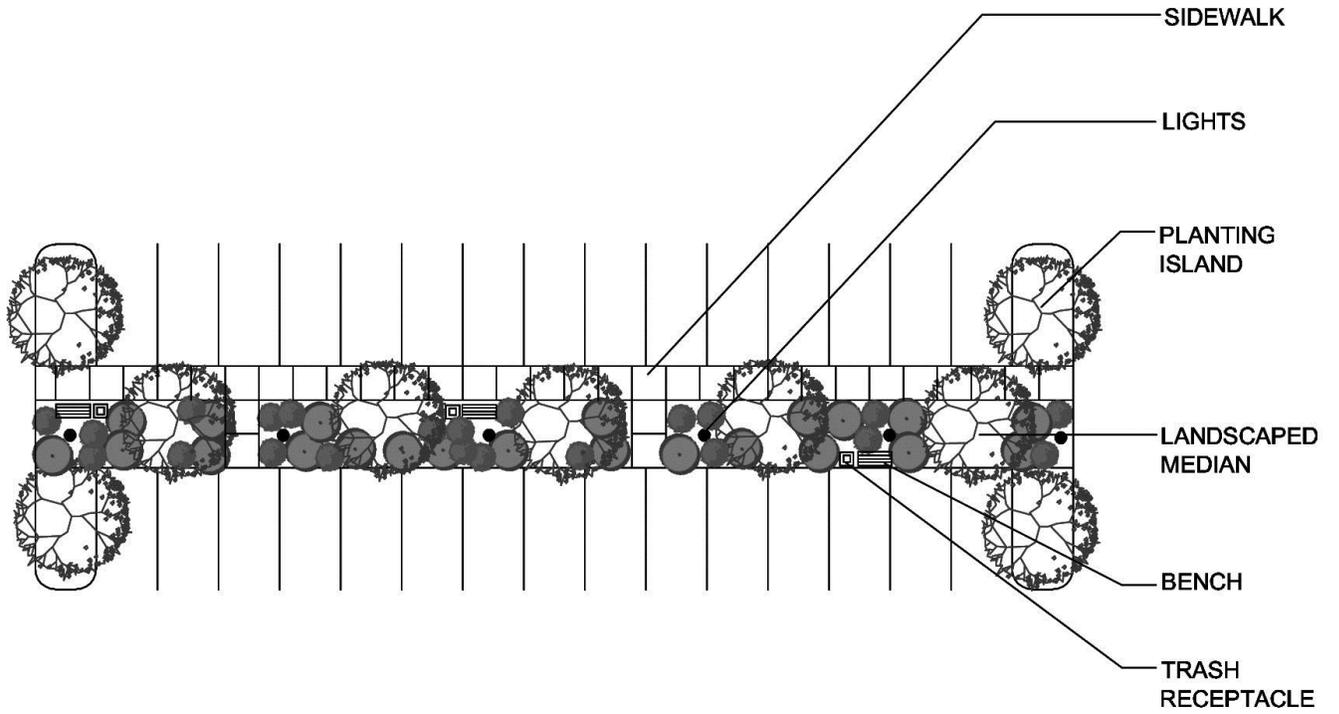


Figure 2.3-2 Planting Strip with Overhead Power Lines



Section 2.4 – Landscaped Medians

Figure 2.4-1 Landscaped Median within a Parking Area



Section 2.5 – Recommended Native/Naturalized Plant List

Chart 2.5-1 Large Deciduous Trees:

LATIN NAME	COMMON NAME	STREET TREE	SCREENING	PARKING LOT ISLAND	PLANTING STRIP	GENERAL LANDSCAPING
<i>Acer rubrum</i>	Red Maple	X				X
<i>Acer saccharum</i>	Sugar Maple					X
<i>Aesculus flava</i>	Yellow Buckeye					X
<i>Betula alleghensis</i>	Yellow Birch					X
<i>Betula lenta</i>	Sweet Birch					X
<i>Betula nigra</i>	River Birch					X
<i>Carya glabra</i>	Pignut Hickory					X
<i>Diospyros virginiana</i>	Persimmon					X
<i>Fagus grandifolia</i>	American Beech					X
<i>Fraxinus americana</i>	White Ash	X				X
<i>Fraxinus pensylvanica</i>	Green Ash	X				X
<i>Liquidambar styraciflua</i>	Sweetgum					X
<i>Liriodendron tulipifera</i>	Tulip Poplar					X
<i>Magnolia acuminata</i>	Cucumber Magnolia	X				X
<i>Nyssa sylvatica</i>	Black Gum	X				X
<i>Prunus serrulata</i>	Oriental Cherry					X
<i>Quercus alba</i>	White Oak					X
<i>Quercus coccinea</i>	Scarlet Oak					X
<i>Quercus falcate</i>	Southern Red Oak					X
<i>Quercus palustris</i>	Pin Oak					X
<i>Quercus rubra</i>	Red Oak					X
<i>Quercus stellata</i>	Post Oak					X
<i>Quercus velutina</i>	Black Oak					X
<i>Tilia cordata</i>	Littleleaf Linden	X				X
<i>Tilia americana</i>	American Linden					X

Chart 2.5-2 Small Deciduous Trees:

LATIN NAME	COMMON NAME	STREET TREE	SCREENING	PARKING LOT ISLAND	PLANTING STRIP	GENERAL LANDSCAPING	FLOWERING
<i>Amelanchier arborea</i>	Downy Serviceberry			X	X	X	X
<i>Amelanchier canadensis</i>	Canada Serviceberry			X	X	X	X
<i>Amelanchier laevis</i>	Smooth Serviceberry			X	X	X	X
<i>Asimina triloba</i>	Paw Paw Tree					X	
<i>Cercis canadensis</i>	Eastern Redbud			X	X	X	X
<i>Chionanthus virginicus</i>	Fringetree			X	X	X	X
<i>Cornus alternifolia</i>	Alternate Leaf Dogwood			X	X	X	X
<i>Cornus florida</i>	Flowering Dogwood			X	X	X	X
<i>Crateagus crus-galli</i>	Cockspur Hawthorne		X	X		X	
<i>Crataegus flava</i>	October Hawthorne		X	X		X	
<i>Halesia tetraptera</i>	Carolina Silverbell			X		X	X
<i>Morus rubra</i>	Red Mulberry			X	X	X	
<i>Ostra virginiana</i>	Eastern Hop Hornbeam						
<i>Prunus americana</i>	American Wild Plum		X	X	X	X	X
<i>Rhus glabra</i>	Smooth Sumac		X		X	X	
<i>Salix nigra</i>	Black Willow					X	X
<i>Syringa vulgaris</i>	Common Lilac					X	X

Chart 2.5-3 Large Evergreen Trees:

LATIN NAME	COMMON NAME	STREET TREE	SCREENING	PARKING LOT ISLAND	PLANTING STRIP	GENERAL LANDSCAPING
<i>Ilex opaca</i>	American Holly		X			X
<i>Juniperus virginiana</i>	Eastern Red Cedar		X			X
<i>Magnolia grandiflora</i>	Southern Magnolia		X			X
<i>Picea glauca</i>	White Spruce		X			X
<i>Picea abies</i>	Norway Spruce		X			X
<i>Picea orientalis</i>	Oriental Spruce		X			X
<i>Pinus bungeana</i>	Lacebark Pine		X			X
<i>Pinus echinata</i>	Shortleaf Pine		X			X
<i>Pinus koraiensis</i>	Korean Pine		X			X
<i>Pinus virginiana</i>	Virginia Pine		X			X
<i>Thuja occidentalis</i>	White Cedar		X			X
<i>Tsuga canadensis</i>	Eastern Hemlock		X			X
<i>Tsuga caroliniana</i>	Carolina Hemlock		X			X

Chart 2.5-4 Large Evergreen Shrubs & Small Evergreen Trees:

LATIN NAME	COMMON NAME	STREET TREE	SCREENING	PARKING LOT ISLAND	PLANTING STRIP	GENERAL LANDSCAPING
<i>Buxus sempervirens</i>	Common Boxwood		X	X	X	X
<i>Camellia oleifera</i>	Tea Oil Camellia					X
<i>Chamaecyparis obtuse</i>	Hinoki Falsecypress			X	X	X
<i>Ilex × attenuate</i>	Foster's Holly		X	X	X	X
<i>Ilex verticillata</i>	Winterberry Holly		X	X	X	X
<i>Juniperus chinensis</i>	Chinese Juniper		X	X	X	X
<i>Magnolia virginiana</i>	Sweet Bay Magnolia					X
<i>Picea glauca 'conica'</i>	Dwarf White Spruce		X	X	X	X
<i>Thuja occidentalis</i>	Eastern Arborvitae		X	X	X	X

Chart 2.5-5 Large Deciduous Shrubs:

LATIN NAME	COMMON NAME	STREET TREE	SCREENING	PARKING LOT ISLAND	PLANTING STRIP	GENERAL LANDSCAPING	FLOWERING
<i>Acer palmatum</i>	Japanese Maple					X	
<i>Aronia pyrifolia</i>	Red Chokeberry					X	X
<i>Callicarpa americana</i>	American Beautyberry					X	X
<i>Calycanthus floridus</i>	Eastern Sweetshrub					X	X
<i>Chaenomeles × superb</i>	Flowering Quince				X	X	X
<i>Clethra alnifolia</i>	Summersweet				X	X	X
<i>Cornus amomum</i>	Silky Dogwood			X	X	X	X
<i>Cornus sericea</i>	Redosier Dogwood			X	X	X	X
<i>Cornus alba 'Sibirica'</i>	Tatarian Dogwood			X	X	X	X
<i>Cotinus coggygria</i>	Smokebush				X	X	X
<i>Fothergilla major</i>	Large Fothergilla					X	X
<i>Hydrangea paniculata</i>	Panicle Hydrangea					X	X
<i>Hydrangea quercifolia</i>	Oak Leaf Hydrangea					X	X
<i>Lagerstroemia indica</i>	Crape Myrtle			X	X	X	X
<i>Morella pensylvanica</i>	Northern Bayberry			X	X	X	
<i>Physocarpus opulifolius</i>	Ninebark			X	X	X	
<i>Rhododendron calendulaceum</i>	Flame Azalea			X	X	X	X
<i>Rhododendron</i>	Pinxterbloom Azalea			X	X	X	X
<i>Rhododendron prinophyllum</i>	Roseshell Azalea			X	X	X	X
<i>Rhus aromatic</i>	Fragrant Sumac			X	X	X	
<i>Salix purpurea 'Nana'</i>	Dwarf Purpleosier Willow					X	X
<i>Sambucus nigra 'Variegata'</i>	Variegated Elderberry			X	X	X	X
<i>Spiraea prunifolia</i>	Bridalwreath Spirea			X	X	X	X
<i>Viburnum carlesii</i>	Korean Spice Viburnum			X	X	X	X
<i>Viburnum burkwoodii</i>	Burkwood Viburnum			X	X	X	X
<i>Viburnum juddii</i>	Judd Viburnum			X	X	X	X
<i>Viburnum dentatum</i>	Arrowood Viburnum			X	X	X	X
<i>Viburnum macrocephalum</i>	Large Flowered Chinese			X	X	X	X
<i>Viburnum nudum</i>	Possumhaw Viburnum			X	X	X	X
<i>Viburnum acerifolium</i>	Mapleleaf Viburnum			X	X	X	X
<i>Weigela florida</i>	Flowering Weigela			X	X	X	X

Chart 2.5-6 Groundcover & Small Shrubs (Evergreen & Deciduous):

LATIN NAME	COMMON NAME	STREET TREE	SCREENING	PARKING LOT ISLAND	PLANTING STRIP	GENERAL LANDSCAPING	FLOWERING
<i>Cotoneaster dammeri</i> 'Coral Beauty'	Coral Beauty Cotoneaster			X		X	X
<i>Festuca glauca</i> 'Boulder Blue'	Boulder Blue Fescue			X		X	
<i>Hosta</i>	Hosta, Plantain Lily					X	X
<i>Hypericum reptans</i>	Creeping St. John's Wort			X	X	X	X
<i>Iberis sempervirens</i> 'Little Gem'	Little Gem Candytuft			X		X	X
<i>Juniperus horizontalis</i>	Creeping Juniper			X		X	
<i>Liriope muscari</i>	Liriope			X		X	
<i>Pachysandra terminalis</i>	Pachysandra			X		X	X
<i>Phlox subulata</i>	Moss Pink			X		X	X
<i>Sedum</i>	Stoncrop			X		X	
<i>Yucca filamentosa</i>	Yucca			X		X	

Section 2.6 – Highly Invasive Species

It should be noted the list is not regulatory in nature, and thus does not prohibit the use of the listed plant species.

Chart 2.6-1 Highly Invasive Species List

LATIN NAME	COMMON NAME
<i>Ailanthus altissima</i>	Tree-of-Heaven
<i>Alliaria petiolata</i>	Garlic Mustard
<i>Alternanthera philoxeroides</i>	Alligator Weed
<i>Ampelopsis brevipedunculata</i>	Porcelain-Berry
<i>Carex kobomugi</i>	Asiatic Sand Sedge
<i>Celastrus orbiculata</i>	Oriental Bittersweet
<i>Centaurea dubia</i>	Short-Fringed Knapweed
<i>Centaurea biebersteinii</i>	Spotted Knapweed
<i>Cirsium arvense</i>	Canada Thistle
<i>Dioscorea oppositifolia</i>	Chinese Yam
<i>Elaeagnus umbellata</i>	Autumn Olive
<i>Euonymus alata</i>	Winged Burning Bush
<i>Hydrilla verticillata</i>	Hydrilla
<i>Imperata cylindrica</i>	Cogon Grass
<i>Lespedeza cuneata</i>	Chinese Lespedeza
<i>Ligustrum sinense</i>	Chinese Privet
<i>Lonicera japonica</i>	Japanese Honeysuckle
<i>Lonicera morrowii</i>	Morrow's Honeysuckle
<i>Lonicera standishii</i>	Standish's Honeysuckle
<i>Lythrum salicaria</i>	Purple Loosestrife
<i>Microstegium vimineum</i>	Japanese Stilt Grass
<i>Murdannia keisak</i>	Aneilema
<i>Myriophyllum aquaticum</i>	Parrot Feather
<i>Myriophyllum spicatum</i>	European Water-Milfoil
<i>Phragmites australis</i>	Common Reed
<i>Polygonum cuspidatum</i>	Japanese Knotweed
<i>Polygonum perfoliatum</i>	Mile-A-Minute
<i>Pueraria montana</i>	Kudzu Vine
<i>Ranunculus ficaria</i>	Lesser Celandine
<i>Rosa multiflora</i>	Multiflora Rose
<i>Rubus phoenicolasius</i>	Wineberry
<i>Sorghum halepense</i>	Johnson-Grass

Section 2.7 – Native Plant Guide for Stormwater Management Areas in the Mid-Atlantic, USA from the Virginia State Stormwater Management Handbook, Volume 1, Chapter 3

Chart 2.7-1 Trees and Shrubs

Tree/Shrub	*Zone	Form	Available	Inundation Tolerance	Wildlife Value	Notes
American Beech (<i>Fagus grandifolia</i>)	5,6	Dec. Tree	no	no	High, mammals and birds.	Prefers shade and rich, well-drained soils.
American Holly (<i>Ilex opaca</i>)	5,6	Dec. Tree	yes	some	High, songbirds, food, cover, nesting.	Coastal plain only. Prefers shade and rich soils.
American Hornbeam (<i>Carpinus caroliniana</i>)	4,5	Dec. Tree	yes	yes	Moderate, food, browsing.	Most common in flood plains and bottom land of Piedmont and mountains.
Arrowwood Viburnum (<i>Viburnum dentatum</i>)	2,3,4	Dec. Shrub	yes	no	High, songbirds and mammals.	Grows best in sun to partial shade.
Bald Cypress (<i>Taxodium distichum</i>)	3,4	Dec. Tree	yes	yes	Little food value but good perching site for waterfowl.	Forested Coastal Plain wetlands. North of normal range. Tolerates drought.
Bayberry (<i>Myrica pensylvanica</i>)	4,5,6	Dec. Shrub	yes	no	High, nesting, food cover. Berries last into winter.	Coastal Plain only. Roots fix N. Tolerates slightly acidic soil.
Bitternut Hickory (<i>Carya cordiformis</i>)	3,4,5	Dec. Tree	no	yes	High, food.	Moist soils or wet bottom land areas.
Black Cherry (<i>Prunus serotina</i>)	5,6	Dec. Tree	yes	yes	High, fruit is eaten by many birds.	Temporarily flooded forested areas. Possible fungus infestation.
Black Walnut (<i>Juglans nigra</i>)	5,6	Dec. Tree	yes	yes	High, food.	Temporarily flooded wetlands along flood plains. Well drained, rich soils.
Blackgum or Sourgum (<i>Nyssa sylvatica</i>)	4,5,6	Dec. Tree	yes	yes	High, songbirds, egrets, herons, raccoons, owls.	Can be difficult to transplant. Prefers sun to partial shade.
Black Willow (<i>Salix nigra</i>)	3,4,5	Dec. Tree	yes	yes	High, browsing and cavity nesters.	Rapid growth, stabilizes stream banks. Full sun.
Buttonbush (<i>Cephalanthus occidentalis</i>)	2,3,4,5	Dec. Shrub	yes	yes	High, ducks and shorebirds. Seeds, nectar and nesting.	Full sun to partial shade. Will grow in dry areas.
Chestnut Oak (<i>Quercus prinus</i>)	5,6	Dec. Tree	no	no	High. Cover, browse and food.	Gypsy moth target. Dry soils.
Common Choke Cherry (<i>Prunus virginiana</i>)	5,6	Dec. Tree	no	some	High, birds, mammals. Fruit and cover.	Prefers drier conditions.
Common Spicebush (<i>Lindera benzoin</i>)	4,5	Dec. Shrub	yes	no	Very high, songbirds.	Shade and rich soils. Tolerates acidic soils. Good understory species.

Tree/Shrub (continued)	*Zone	Form	Available	Inundation Tolerance	Wildlife Value	Notes
Eastern Cottonwood (<i>Populus deltoides</i>)	4,5	Dec. Tree	yes	yes	Moderate, cover, food.	Shallow rooted, subject to windthrow. Invasive roots. Rapid growth.
Eastern Hemlock (<i>Tsuga canadensis</i>)	5,6	Conif. Tree	yes	yes	Moderate. Mostly cover and some food.	Tolerates all sun/shade conditions. Tolerates acidic soil.
Eastern Red Cedar (<i>Juniperus virginiana</i>)	4,5,6	Conif. Tree	yes	no	High. Fruit for birds. Some cover.	Full sun to partial shade. Common in wetlands, shrub bogs and edge of streams.
Elderberry (<i>Sambucus canadensis</i>)	4,5,6	Dec. Shrub	yes	yes	Extremely high for food and cover, for birds and mammals.	Full sun to partial shade.
Flowering Dogwood (<i>Cornus florida</i>)	4,5,6	Dec. Tree	no	yes	High, birds, food.	Prefers rich, moist soils. Dogwood anthracnose possible problem.
Fringe Tree (<i>Chionanthus virginicus</i>)	3,4,5	Dec. Shrub or small tree	yes	some	Moderate. Food and cover.	Full sun to partial shade. Tolerates acidic soil.
Green Ash, Red Ash (<i>Fraxinus pennsylvanica</i>)	4,5	Dec. Tree	yes	yes	Moderate, songbirds.	Rapid growing stream bank stabilizer. Full sun to partial shade.
Hackberry (<i>Celtis occidentalis</i>)	5,6	Dec. Tree	yes	yes	High, food and cover.	Full sun to partial shade.
Ironwood/ Hophornbeam (<i>Ostrya virginiana</i>)	5,6	Dec. Tree	yes	yes	Moderate, food and browse.	Tolerant of all sunlight conditions.
Larch, Tamarack (<i>Larix laricina</i>)	3,4	Conif. Tree	no	yes	Low, nest tree and seeds.	Rapid initial growth. Full sun, acidic boggy soils.
Loblolly Pine (<i>Pinus taeda</i>)	5,6	Conif. Tree	yes	yes	Moderate, food, nesting, squirrels.	Coastal Plain only. Tolerant of extreme soil conditions.
Mountain Laurel (<i>Kalmia latifolia</i>)	6	Evergreen	no	some	Low, cover, and nectar. Foliage is toxic to cattle and deer.	Partial shade, acidic soils.
Persimmon (<i>Diospyros virginiana</i>)	4,5,6	Dec. Tree	yes	no	Extremely high, birds, mammals.	Not shade tolerant. Well-drained soils.
Pin Oak (<i>Quercus palustris</i>)	4,5,6	Dec. Tree	yes	yes	High, mast. Tolerates acidic soil.	Gypsy moth target. Prefers sun to partial shade.
Red Chokeberry (<i>Pyrus arbutifolia</i>)	3,4,5	Dec. Shrub	no	yes	Moderate, songbirds.	Bank stabilizer. Partial sun.
Red Maple (<i>Acer rubrum</i>)	4,5,6	Dec. Tree	yes	yes	High, seeds and browse. Tolerates acidic soil.	Rapid growth.
Red Oak (<i>Quercus rubra</i>)	5,6	Dec. Tree	yes	no	High, food and cover.	Gypsy moth target. Prefers well drained, sandy soils.

Tree/Shrub (continued)	*Zone	Form	Available	Inundation Tolerance	Wildlife Value	Notes
River Birch (Betula nigra)	3,4	Dec. Tree	yes	yes	Low, but good for cavity nesters.	Bank erosion control. Full sun.
Scarlet Oak (Quercus coccinea)	3,4	Dec. Tree	no	no	High, food and cover.	Gypsy moth target. Difficult to transplant.
Shadbush, Serviceberry (Amelanchier canadensis)	5,6	Dec. Tree	yes	yes	High, nesting, cover and food. Birds and mammals.	Prefers partial shade. Common in forested wetlands and upland woods.
Silky Dogwood (Cornus amomum)	5,6	Dec. Shrub	yes	yes	High, songbirds, mammals.	Shade and drought tolerant. Good bank stabilizer.

Chart 2.7-2 Wetland Plants

Wetland Plants	*Zone	Form	Available	Inundation Tolerance	Wildlife Value	Notes
Arrow arum (Peltandra virginica)	2	Emergent	yes	up to 1 ft.	High, berries are eaten by wood ducks.	Full sun to partial shade.
Arrowhead/Duck potato (Sagittaria latifolia)	2	Emergent	yes	up to 1 ft.	Moderate, tubers and seeds eaten by ducks.	Aggressive colonizer.
Broomsedge (Andropogon virginianus)	2,3	Perimeter	yes	up to 3 in.	High, songbirds and browsers. Winter food and cover.	Tolerant of fluctuating water levels and partial shade.
Cattail (Typha spp.)	2,3	Emergent	yes	up to 1 ft.	Low, except as cover.	Aggressive. May eliminate other species. Volunteer. High pollutant treatment.
Coontail (Ceratophyllum demersum)	1	Submergent	no	yes	Low, food, good habitat and shelter for fish and invertebrates.	Free floating SAV. Shade tolerant. Rapid growth.
Common Three Square (Scirpus pungens)	2	Emergent	yes	up to 6 in.	High, seeds, cover, waterfowl, songbirds.	Fast colonizer. Can tolerate periods of dryness. Full sun. High metal removal.
Duckweed (Lemna sp.)	1,2	Submergent /Emergent	yes	yes	High, food for waterfowl and fish.	May biomagnify metals beyond concentrations found in water.
Lizard's Tail (Saururus cernuus)	2	Emergent	yes	up to 1 ft.	Low, except wood ducks.	Rapid growth. Shade tolerant.
Marsh Hibiscus (Hibiscus moscheutos)	2,3	Emergent	yes	up to 3 in.	Low, nectar.	Full sun. Can tolerate periodic dryness.
Pickerelweed (Pontederia cordata)	2,3	Emergent	yes	up to 1 ft.	Moderate, ducks, nectar for butterflies.	Full sun to partial shade.

Wetland Plants (continued)	*Zone	Form	Available	Inundation Tolerance	Wildlife Value	Notes
Pond Weed (Potamogeton pectinatus)	1	Submergent	yes	yes	Extremely high, waterfowl, marsh and shore-birds.	Removes heavy metals.
Rice Cutgrass (Leersia oryzoides)	2,3	Emergent	yes	up to 3 in.	High, food and cover.	Full sun, although tolerant of shade. Shoreline stabilization.
Sedges (Carex spp.)	2,3	Emergent	yes	up to 3 in.	High, waterfowl, songbirds.	Many wetland and several upland species.
Soft-stem Bulrush (Scipus validus)	2,3	Emergent	yes	up to 1 ft.	Moderate, good cover and food.	Full sun. Aggressive colonizer. High pollutant removal.
Smartweed (Polygonum spp.)	2	Emergent	yes	up to 1 ft.	High, waterfowl, songbirds, seeds and cover.	Fast colonizer. Avoid weedy aliens such as P. Perfoliatum.
Spatterdock (Nuphar luteum)	2	Emergent	yes	up to 1.5 ft.	Moderate, for food but high for cover.	Fast colonizer. Tolerant of fluctuating water levels.
Switchgrass (Panicum virgatum)	2,3,4, 5,6	Perimeter	yes	up to 3 in.	High, seeds, cover. Waterfowl, songbirds.	Tolerates wet/dry conditions.
Sweet Flag (Acorus calamus)	2,3	Perimeter	yes	up to 3 in.	Low, tolerant of dry periods.	Tolerates acidic conditions. Not a rapid colonizer.
Waterweed (Elodea canadensis)	1	Submergent	yes	yes	Low.	Good water oxygenator. High nutrient, copper, manganese and chromium removal.
Wild Celery (Valisneria americana)	1	Submergent	yes	yes	High, food for waterfowl. Habitat for fish and invertebrates.	Tolerant of murkey water and high nutrient loads.
Wild Rice (Zizania aquatica)	2	Emergent	yes	up to 1 ft.	High, food. Birds.	Prefers full sun.

Zone 1: Submergent Aquatic Vegetation

Zone 2: Shallow Water Bench - 6-12 inches Deep

Zone 3: Shoreline Fringe - Regularly Inundated Area

Zone 4: Riparian Fringe - Periodically Inundated Area, Wet Soils

Zone 5: Floodplain Terrace - Infrequently Inundated, Moist Soils

Zone 6: Upland Slopes - Seldom or Never Inundated, Moist To Dry Soils

Chapter 3: Transportation

Section 3.1 – Parking Area Design

(A) Automobile Parking Diagrams and Dimensions

Figure 3.1-1 Standard Parking Space and Aisle Dimensions

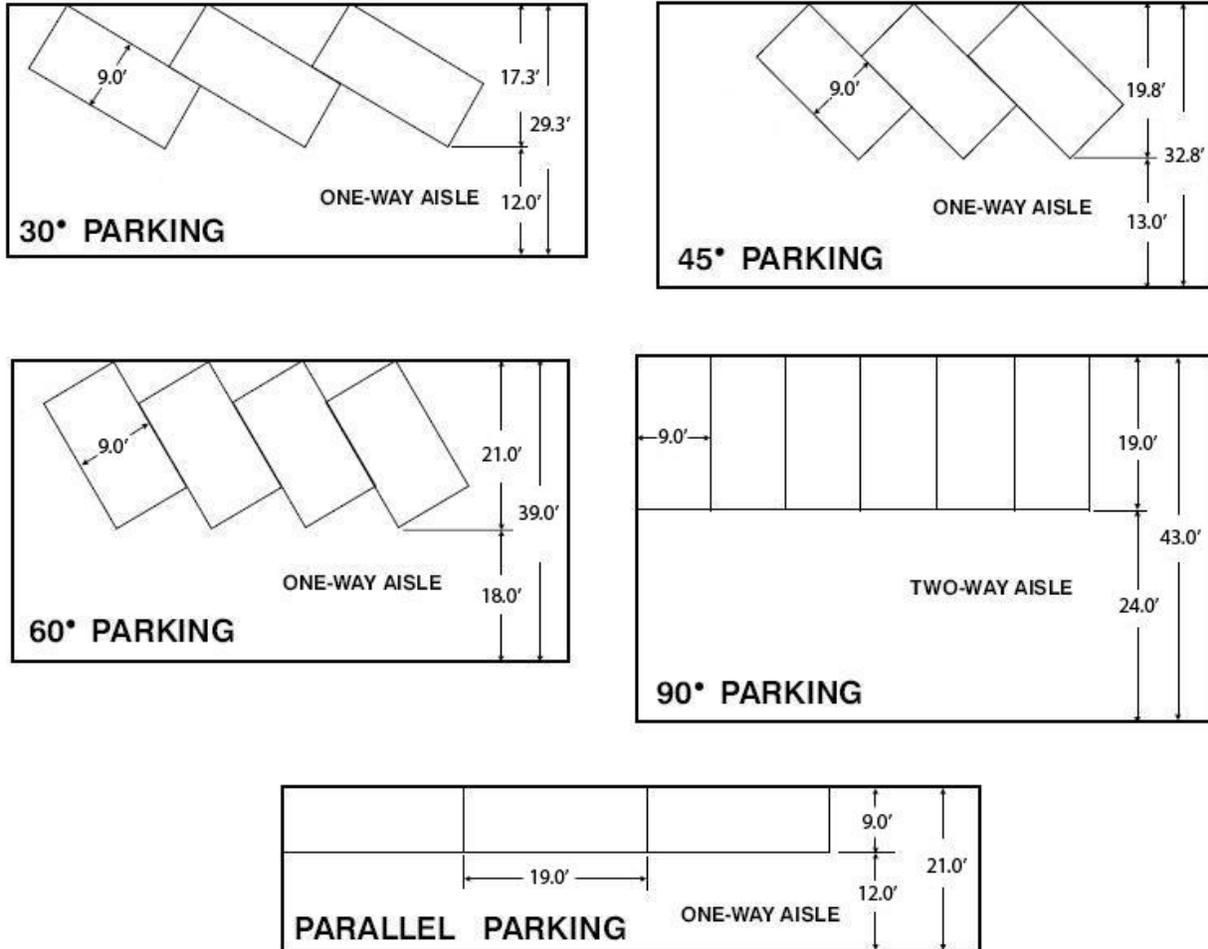
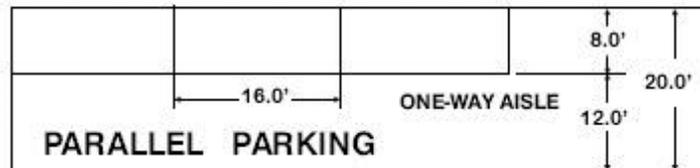
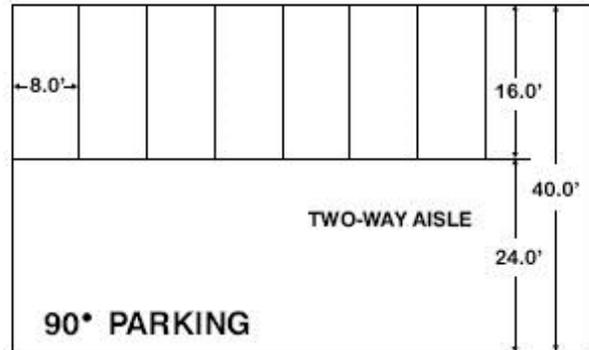
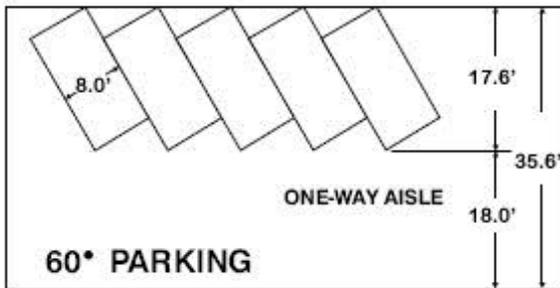
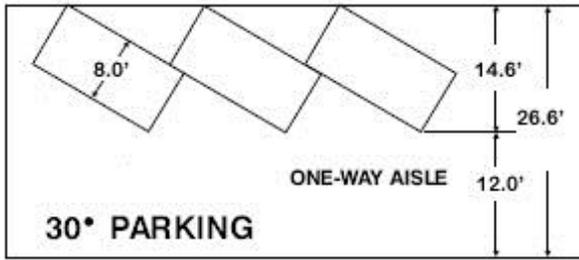


Figure 3.1-2 Compact Parking Space and Aisle Dimensions



(B) Bicycle Parking

Chart 3.1-1 Bicycle Parking Standards				
Impervious Spaces Provided	Bicycle Spaces Required*	Extra Bicycle Spaces Provided	Total Bicycle Spaces Provided	Maximum Impervious Space Reduction** (Extra Spaces / 4)
20	0	4	4	1
50	3	4	7	1
75	4	12	16	3
100	5	20	25	5
150	8	28	36	7
200	10	40	50	10
250	13	48	61	12
300	15	60	75	15
350	18	68	86	17
400	20	90	110	20

*No more than 20 bicycle spaces shall be required

** The number of impervious spaces that can be reduced is calculated by dividing the extra bicycle spaces provided by four. Impervious vehicular parking spaces reduced shall not exceed 5% of the total impervious spaces provided.

Figure 3.1-3 Bicycle Sign Examples



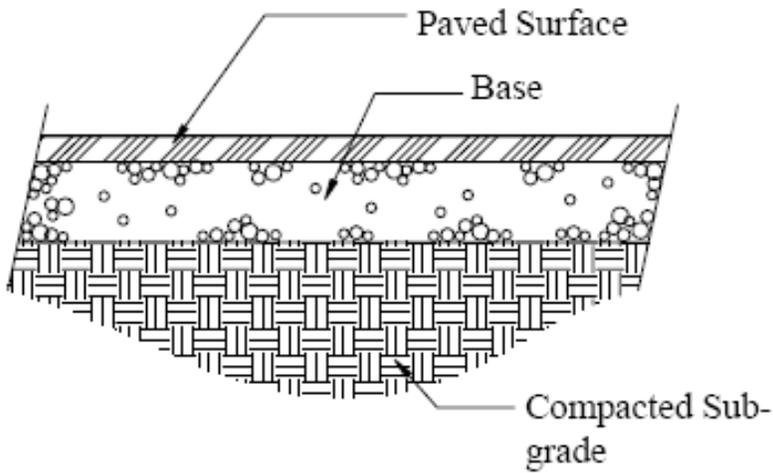
Figure 3.1-4 Bicycle Racks



Chart 3.1-2 Bicycle Rack Recommended Features	
1.	Support the bicycle upright by at least two points of contact
2.	Prevent the wheel of the bicycle from tipping over
3.	Enable the frame and one or both of the wheels to be secured
4.	Accommodate a U-Shaped locking device
5.	Lock the frame and both wheels to the rack with a chain or cable not longer than six (6) feet

Section 3.2 – Typical Paving

Figure 3.2-1 Impervious Pavement Cross Section



Section 3.3 – Permeable Paving

Figure 3.3-1 Permeable Paver Cross Section

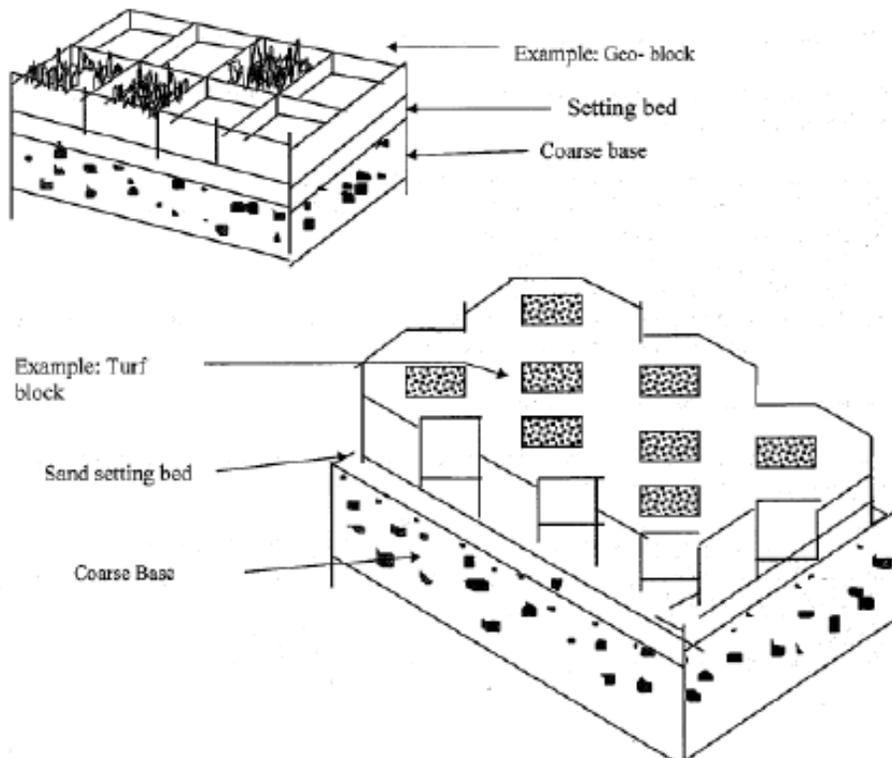
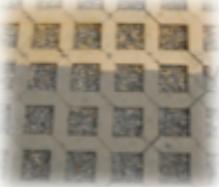
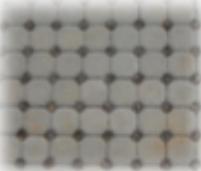


Chart 3.3-1 Examples of Permeable Pavement Surfaces

Permeable Surface	Description	Applications	Limitations	Maintenance
<p>Permeable Interlocking Concrete Pavers (PICP)</p> 	<p>Cast-in-place systems or modular pre-cast blocks that have wide joints or openings that are filled with gravel or soil and grass.</p>	<ul style="list-style-type: none"> • Low volume drive areas • Overflow parking • Parking pads • Residential parking • Recreational trails • Pedestrian paths 	<ul style="list-style-type: none"> • Performance depends on site conditions. • Not applicable for high-traffic areas or for use by heavy traffic vehicles 	<ul style="list-style-type: none"> • Periodically add joint material to replace material that has been moved/worn down by traffic and/or weather • Easy to repair, since units are easily lifted and reset
<p>Concrete Grid Pavers</p> 	<p>Pavement surface consisting of strong structural materials having regularly interspersed void areas which are filled with pervious materials, such as sod, gravel or sand.</p>	<ul style="list-style-type: none"> • Low volume drive areas • Overflow parking • Parking pads • Residential parking • Recreational trails • Pedestrian paths • Emergency vehicle and fire access lanes 	<ul style="list-style-type: none"> • System must be designed with an overflow or lateral release from the storage bed • Performance depends on site conditions. • Not applicable for high-traffic areas or for use by heavy traffic vehicles 	<ul style="list-style-type: none"> • Periodically add joint material to replace material that has been moved/worn down by traffic and/or weather • Easy to repair, since units are easily lifted and reset
<p>Permeable Asphalt</p>  <p>Source: Blue-GreenBuilding.org</p>	<p>Consists of fine and course aggregate stone bound by a bituminous-based binder. The amount of fine aggregate is reduced creating larger void spaces which allow water to infiltrate.</p>	<ul style="list-style-type: none"> • Low volume drive areas • Overflow parking • Parking pads • Residential parking • Recreational trails • Pedestrian paths • Emergency vehicle and fire access lanes 	<ul style="list-style-type: none"> • Application must be large enough to be cost effective for supplier to mix material • System must be designed with an overflow or lateral release from the storage bed 	<ul style="list-style-type: none"> • Annual vacuum sweeping or high pressure hosing required to maintain function
<p>Porous Concrete</p>  <p>Source: Blue-GreenBuilding.org</p>	<p>Mixture of Portland cement, fly ash, washed gravel and water. Similar to standard pavement in aesthetics and load bearing capacity, but the fine material has been reduced or eliminated in the mix resulting in the formation of channels that allow water to infiltrate.</p>	<ul style="list-style-type: none"> • Low volume drive areas • Overflow parking • Parking pads • Residential parking • Recreational trails • Pedestrian paths • Emergency vehicle and fire access lanes 	<ul style="list-style-type: none"> • Application must be large enough to be cost effective for supplier to mix material • System must be designed with an overflow or lateral release from the storage bed 	<ul style="list-style-type: none"> • Annual vacuum sweeping or high pressure hosing required to maintain function

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Figure 3.3-2 Examples of Permeable Pavement Applications



Modular Concrete Pavers



Parking Lot with Porous Surface



Overflow Parking Area



Concrete Paver Driveway



Low Use Parking Area



Plastic Lattice Turf Pavement

Section 3.4 – Sidewalks

(A) Intent: Sidewalks are encouraged in areas with potential for moderate to high pedestrian activity along public and private rights-of-way, particularly within and between the following areas:

1. High employment
2. Commercial (service) areas
3. Dense residential areas (multifamily and small-lot, single-family residential subdivisions)
4. Public facilities (schools, libraries, parks, recreational centers)

(B) General standards (refer to current VDOT standards^a, as amended, for additional standards and detail)

1. Materials:
 - a. Concrete which may be stamped and colored; or
 - b. Solid paving units such as brick or concrete.
2. Sidewalk depth: 4 inches minimum
3. Curb Ramps: Provide at all road intersections and crosswalks^b

Chart 3.4-1 Sidewalk and Planting Strip Standards

Location	Adjacent to Curb	Sidewalk Width		Sidewalk Clear Width**	Planting Strip / Buffer Width			
		Minimum	Recommended		With Street Trees		Without Street Trees	
					Minimum	Recommended	Minimum	Recommended
Concentrated Business Areas or High Pedestrian Volumes	No	10	10 to 15	10	6	6	3	5 to 6
Other Business Areas	No	5	6 to 8	5	6	6	3	5 to 6
	Yes	8	8 to 10	5	n/a		n/a	
Residential Areas on Public (VDOT) Roads	No	5		4	6		3	
	Yes	8		4	n/a		n/a	
Residential Areas on Private Roads	No	4*	5	4	4	6	2	2 to 4
	Yes	5	6	4	n/a		n/a	

*Sidewalks less than 5 feet in width shall have 5-foot-wide passing spaces located at reasonable intervals.
** Sidewalk clear width is the portion of sidewalk that excludes obstructions and any attached curb (AASHTO)

Section 3.5 – Shared Use Paths

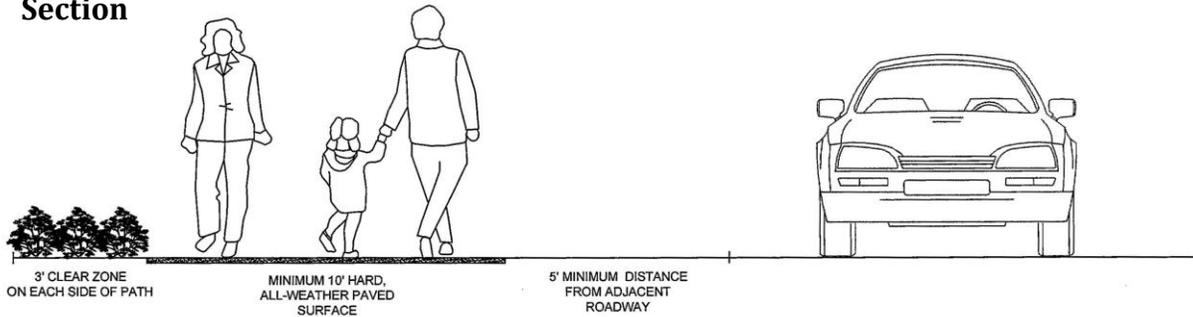
- (A) Intent: Two-directional shared use paths are encouraged to be constructed in locations along public roads where pedestrians, bicyclists and other non-motorized users (and including motorized wheelchair users) can utilize the path either as a recreational amenity in itself or as a means to get from one location to another. Accessibility should be a fundamental consideration in the design and development of shared use paths.^c
- (B) General Standards (refer to current VDOT and AASHTO standards, as amended, for additional standards and detail)
1. Material: Hard, all-weather pavement surface

2. Width:
 - a. 10 feet minimum with a 2-foot-wide graded area adjacent to both sides of the path^d
 - b. 8 feet minimum with a 2-foot-wide graded area adjacent to both sides of the path may be permitted when one or more of the following conditions are present^e:
 - i. Bicycle traffic is expected to be low, even on peak days or during peak hours,
 - ii. Pedestrian use of the facility is not expected to be more than occasional,
 - iii. There will be good horizontal and vertical alignment providing safe and frequent passing opportunities, and
 - iv. During normal maintenance activities the path will not be subjected to maintenance vehicle loading conditions that would cause pavement edge damage.
3. Location: 5 feet minimum from edge of pavement or less with a suitable physical barrier between the path and the edge of the shoulder^f
4. Grade: The path should generally match the grade of the road and should not exceed 5 percent except for short distances as referenced in the chart below:

Chart 3.5-1 Shared Use Path Grades Permitted	
Grade (percent)	Maximum Length (feet)
5-6	800
7	400
8	300
9	200
10	100
11+	50
<i>Based on the 1999 AASHTO Guide for the Development of Bicycle Facilities^g</i>	

5. Clear zone: 3 feet wide on either side of the path^h
6. Curb Ramps: Provide at all road intersections and crosswalksⁱ

Figure 3.5-1 – Shared Use Path Cross Section



Section 3.6 – Trails

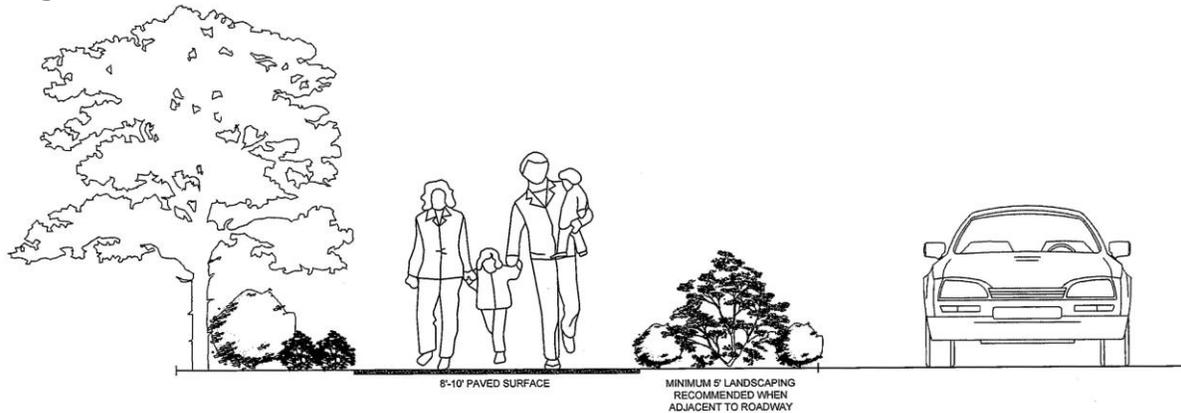
(A) Intent: Private trails may be constructed in residential, commercial, industrial or other types of developments as recreational amenities or as a means to get from one location to another. Users may include pedestrians, bicyclists, equestrians, and persons in wheelchairs. These regulations are not intended for public trails which are typically located within public lands.

(B) Design Considerations: Trails should be designed to be sustainable in order to protect the environment, to meet the needs of users, to require little maintenance and to minimize conflict between different user groups.^j Trails should be designed with a natural shape and should consider anchors, edges, gateways^k and incorporating loops to maximize trail interest. Well-designed trails take advantage of natural land features.^l

(C) General Standards

1. Hard Surface Trails

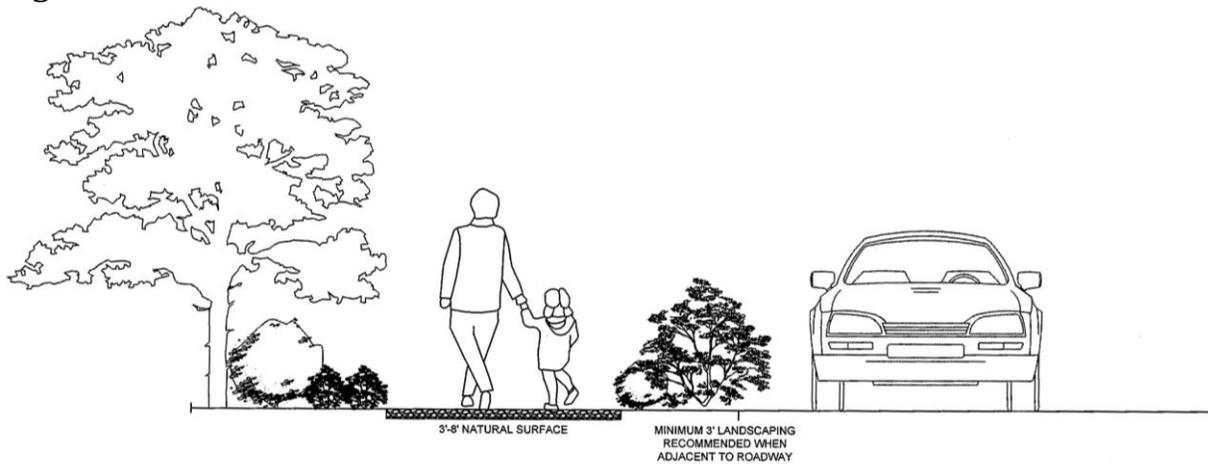
- a. Trail Width: 4 feet wide, minimum
- b. Trail Corridor Clearing Limit Recommendation: Trim vegetation and remove obstacles within two feet of either side of the trail.
- c. Trail Ceiling Recommendation: 8 feet high, 10 feet high if equestrian use is anticipated^m
- d. Road Separation: 2 foot minimum grass strip or landscaped buffer

Figure 3.6-1 – Hard Surface Trail Cross Section

2. Natural Surface Trails

- a. Trail Width: 3 feet wide, minimum, unless a narrower trail width is required by a state or federal agency.
- b. Trail Corridor Clearing Limit Recommendation: Trim vegetation to the ground and remove obstacles within one foot of either side of the trailⁿ.
- c. Trail Ceiling Recommendation: 8 feet high, 10 feet high if equestrian use is anticipated^o
- d. Grade: The average trail grade should be 10 percent or less to be most sustainable^p. The maximum sustainable trail grade is typically 15 to 20 percent^q and should not be exceeded. Follow the Half Rule that a trail's grade should not exceed half the grade of the hillside or sideslope that the trail traverses^r.
- e. Accommodating Erosion: Design rolling contour trails with gentle grades, grade reversals every 20 to 50 feet and a tread with a five percent outslope. Avoid locating trails along fall lines or within flat areas that will collect water^s.
- f. Riparian Areas: Riparian vegetation shall be carefully considered in the planning and construction of trails in riparian areas. Wherever possible, the disturbance of existing vegetation shall be minimized and native and non-invasive species shall be planted to mitigate losses.
- g. Road Separation: 2 foot minimum grass strip or landscaped buffer

Figure 3.6-2 – Natural Surface Trail Cross Section



2. Acceptable Trail Materials

Chart 3.6-1 Acceptable Trail Materials and Standards

Material	Hard Surface	Natural Surface	Minimum Thickness	Accessible	Appropriate Uses
Asphalt	X		3 inches	yes	Pedestrian, Bicycle
Concrete	X		4 inches	yes	Pedestrian, Bicycle
Synthetic Rubber	X		3 inches	yes	Exercise/Fitness
Compacted Aggregate: 3/8" Natural Fines		X	6 inches	yes	Pedestrian, Bicycle, Equestrian
Crushed Stone: #10 Compacted Fines		X	21A Compacted Base with 2 inches on top	no	Pedestrian, Mountain Bicycle, Equestrian
Wood Chip		X	3 inches	no	Pedestrian, Equestrian
Compacted Soil		X	N/A	no	Pedestrian, Bicycle, Equestrian
Grass		X	N/A	no	Pedestrian, Mountain Bicycle, Equestrian

4. Steps

- a. Steps placed closely together or spaced far apart may be utilized to climb trails with steeper grades due to varying topography. The material used to construct steps shall match or complement the trail type. For example,

large rocks would complement a gravel trail or wooden railroad ties would complement a wood chip trail.

- b. If placed closely together, the step rise should measure between 6 and 8 inches and the run should measure between 10 and 12 inches. Landings shall measure at least 6.5 feet.^t
- c. A handrail may be installed adjacent to the steps to assist hikers in climbing steep terrain.

5. Easements

- a. Access easements shall be recorded with a width five feet greater than the trail width.

Section 3.7 – Bicycle Accommodations

(A) Applicable regulations for bicycle accommodations:

1. Current VDOT standards, as amended
2. AASHTO Guide for the Development of Bicycle Facilities, as amended
3. Regional bikeway plans, as amended, available from the Roanoke Valley Alleghany Regional Commission and the Roanoke Valley Area Metropolitan Planning Organization

Section 3.8 – Private Roads

(A) Intent

1. The intent of this section is to provide adequate standards for Roanoke County private roads. Such roads may be provided only in selected urban residential developments including the Cluster Subdivision Option, the Planned Residential Development District, Townhouse and Manufactured Home Park developments. Private roads may also be permitted in locations identified by the Zoning Ordinance.
2. For related topics not covered in this section, refer to other County, State or Federal regulations.

(B) Definitions

1. *Alley*: An open way that affords a service (i.e. garbage collection, delivery, mail) means of access to an abutting property, but is not maintained by any local, state, or federal government. (Roanoke County Subdivision Ordinance and Zoning Ordinance) Alleys may also contain underground utilities.
2. *Driveway*: A private roadway providing access for vehicles to a parking space, garage, dwelling, or other structure. (Roanoke County Zoning Ordinance) A driveway is intended to provide access to no more than two dwelling units.
3. *Easement*: A right expressed in recorded writing, given by the owner of land to another party of specific limited use of that land (i.e., access, pedestrian, greenway, drainage, water, sewer, public utility). (Roanoke County Subdivision Ordinance)
4. *Plat, Final*: The plat of a proposed subdivision of land that has been preliminarily approved and signed by the agent as a preliminary plat, subsequently recorded or to be recorded with the Clerk's Office. (Roanoke County Subdivision Ordinance)
5. *Private Street/Road*: A vehicular way owned, operated, provided, and maintained by an individual, developer, homeowners' association, or any other entity other than a local, state, or federal government. (Roanoke County Subdivision Ordinance) A private road is intended to provide access to three or more dwelling units.
6. *Right-of-Way*: A legally established area or strip of land on which an irrevocable public right of passage has been or is to be recorded, and which may be occupied or intended to be occupied by a street, utility service, water main, sanitary or

storm sewer main, or other similar use. (Roanoke County Subdivision Ordinance)

7. *VDOT*: The Virginia Department of Transportation (Roanoke County Subdivision Ordinance)

(C) Design

1. New private roads shall be designed to connect to Local Access Roads or Collectors and shall be designed to provide access to each residential lot.
2. Shoulder and Ditch Section Requirements.
 - a. Intent. Shoulder and ditch sections are intended primarily for Planned Residential Developments characterized by larger residential lots (generally $\frac{1}{4}$ acre or greater) that may have longer driveways that allow parking for several vehicles. Only in rare instances would residents or guests park along the shoulder of a private road.
 - b. General Parking. If shoulders will be frequently utilized for parking, each shoulder shall measure four feet in width^u and shall be constructed of either stone or bituminous pavement. Parking is not recommended along road sections with grades greater than 15 percent.
 - c. Guest Parking. On- or off-street guest parking may be provided but is not required on roads designed with shoulder and ditch.

Chart 3.8-1 Shoulder and Ditch Standards

Projected Traffic Volume (ADT)[^]	Travelway Width (pavement only)	Roadway Width (including shoulders)
0-400	16 ^v	20 ^w
401-600	18 ^x	22 ^y
Over 600	Refer to current VDOT standards, as amended	
<i>Referenced Standards: AASHTO Very Low Rural, 15-40MPH; AASHTO Very Low Local in Urban Areas, 2 or less du/acre</i>		

[^] To find the Average Daily Trip Generation (ADT) for a proposed land use, refer to the Institute of Transportation Engineers (ITE) Manual, as amended.

3. Curb and Gutter Section Requirements.
 - a. Intent. Curb and gutter sections are intended for both Cluster and Planned Residential Development residential neighborhoods that are densely developed with small lot sizes (generally $\frac{1}{4}$ acre or less).

- b. General Parking. Residential lots may have driveways spaced closely together that are shorter in length, allowing for parking of between two and four vehicles in the driveway. Parking is not recommended along road sections with grades greater than 15 percent.
- c. Guest Parking. One-half (1/2) parking space shall be provided for each dwelling unit for guest parking. Any fraction equaling or exceeding one-half (1/2) shall be construed as requiring one (1) full parking space. Parking spaces may be located off-street in a marked space or on-street in compliance with Chart 3.8-2., Curb and Gutter Standards.
- d. Curb and Gutter. Use CG-6, CG-7 or roll-top curb. See 5(e) Curb and Gutter Design for additional information.

Chart 3.8-2 Curb and Gutter Standards			
Projected Traffic Volume (ADT)^	Pavement Widths Only		
	No Parking	Parking One Side	Parking Both Sides
0-400	16	20	24
401-600	18	21	24
Over 600	Refer to current VDOT standards, as amended		
<i>Referenced Standards: AASHTO Very Low Rural, 15-40MPH</i>			

^ To find the Average Daily Trip Generation (ADT) for a proposed land use, refer to the Institute of Transportation Engineers (ITE) Manual, as amended.

Figure 3.8-1 Shoulder and Ditch Typical Private Road Sections

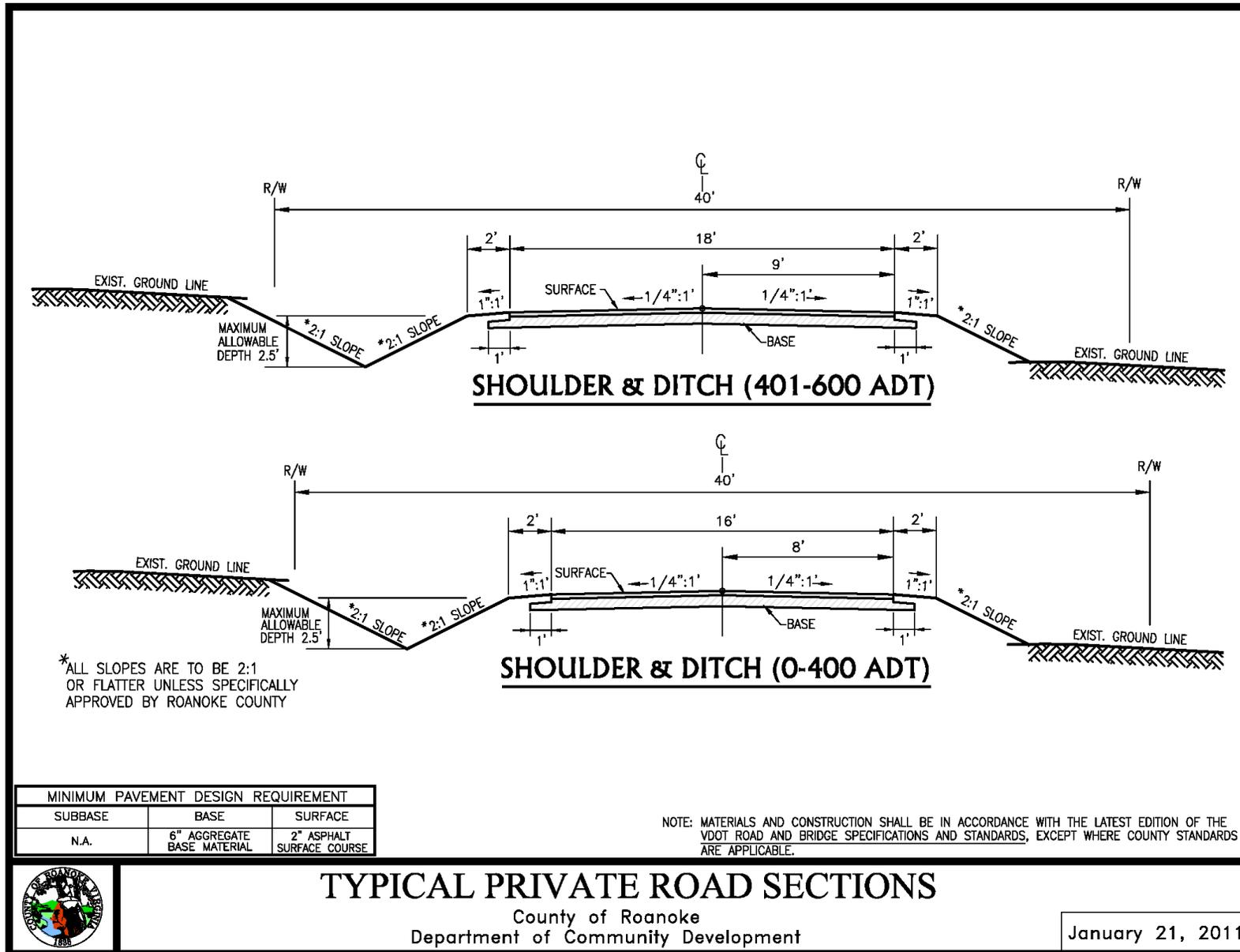
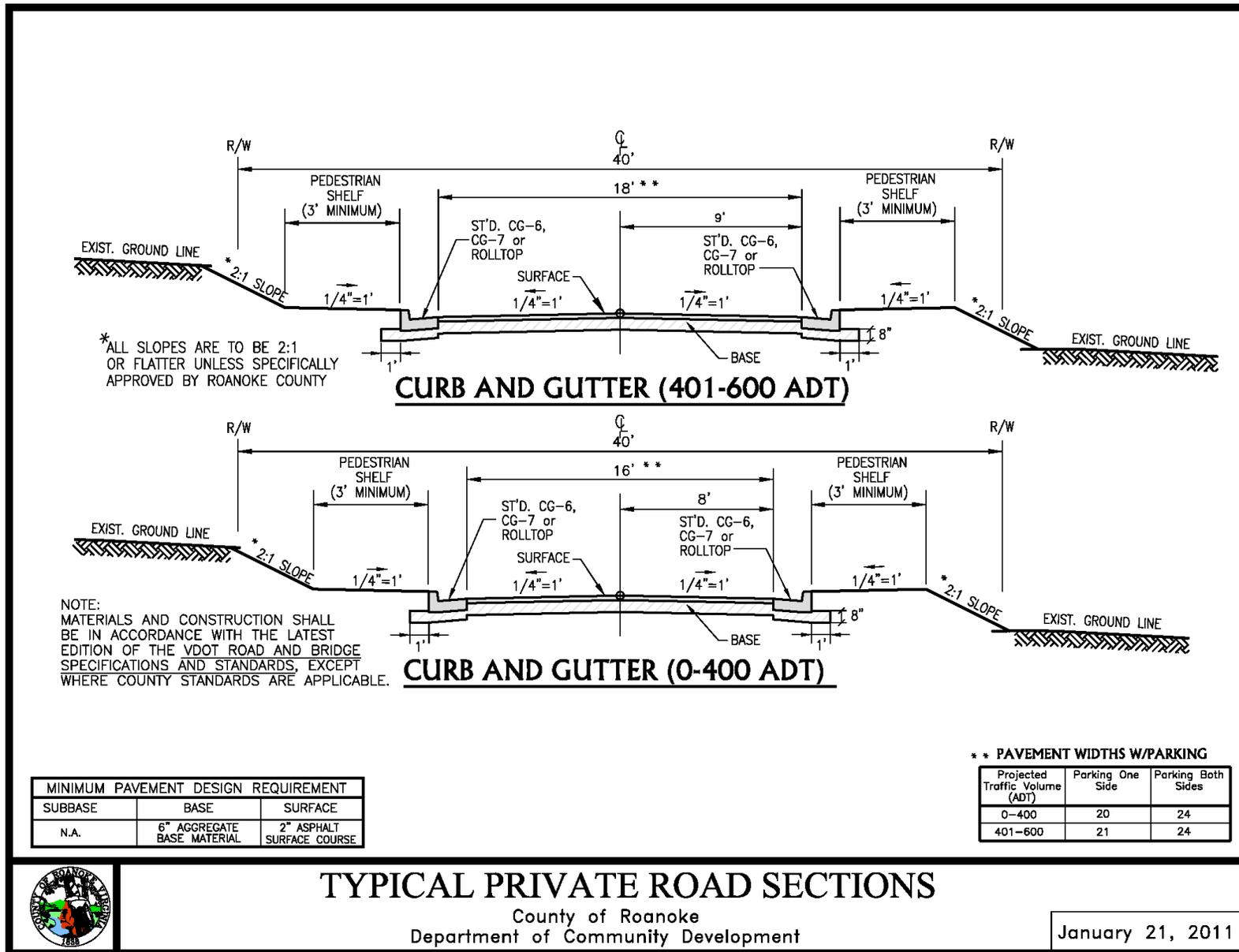


Figure 3.8-2 Curb and Gutter Typical Private Road Sections



TYPICAL PRIVATE ROAD SECTIONS

County of Roanoke
Department of Community Development

January 21, 2011

4. Turnarounds.^z Every effort shall be made to provide through roads within a subdivision to minimize the need for dead end streets. If dead end streets must be used, turnarounds shall be required at the end of all private streets and alleys and are encouraged at the end of all shared driveways.
 - a. Grade: Turnarounds shall have a maximum 5 percent centerline grade with a minimum cross slope of $\frac{1}{4}$ inch to 1 foot.^{aa}
 - b. Landscaped Islands: To reduce impervious area, curbed or un-curbed landscaped islands may be permitted within 45-foot radius or larger cul-de-sacs. The landscaped area shall have a maximum radius of 25 feet and a maximum 5-foot-wide concrete raised median strip (VDOT MS-1^{bb}) may be located along the edge of the island. Bioretention areas may be permitted in such islands.
 - c. Cul-de-sac Parking: To allow access for solid waste collection and other delivery vehicles, parking shall not be permitted in cul-de-sacs with landscaped islands. Parking shall not be permitted on cul-de-sacs with an edge-of-pavement or a face-of-curb radius less than 45 feet. Parking shall be permitted on cul-de-sacs with an edge-of-pavement or a face-of-curb radius of 45 feet or greater.
 - d. Alternative Turnaround Parking: Parking shall not be permitted in T-Type or Branch-Type Turnarounds.

Figure 3.8-3 Shoulder and Ditch Concentric Cul-de-Sacs

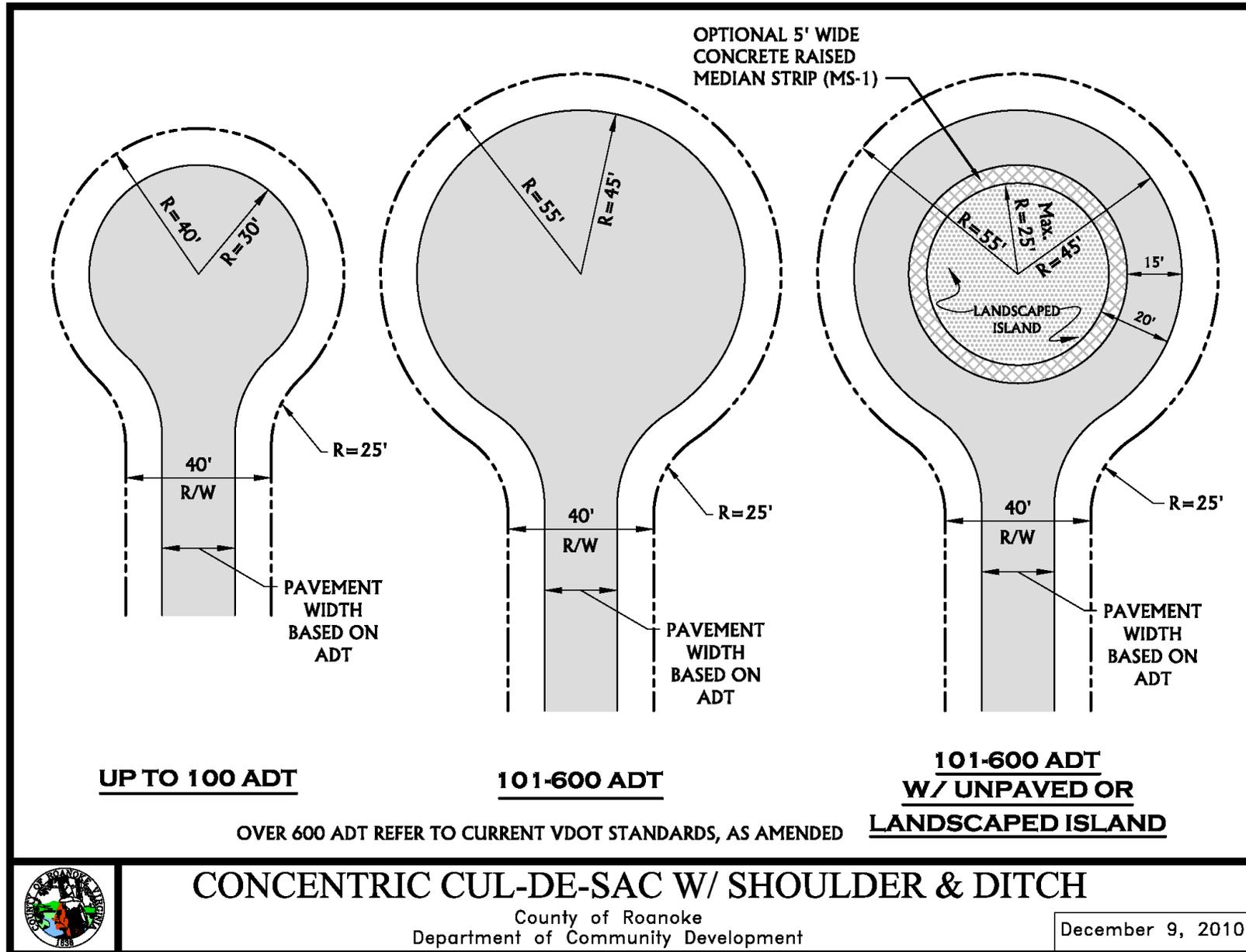


Figure 3.8-4 Curb and Gutter Concentric Cul-de-Sacs

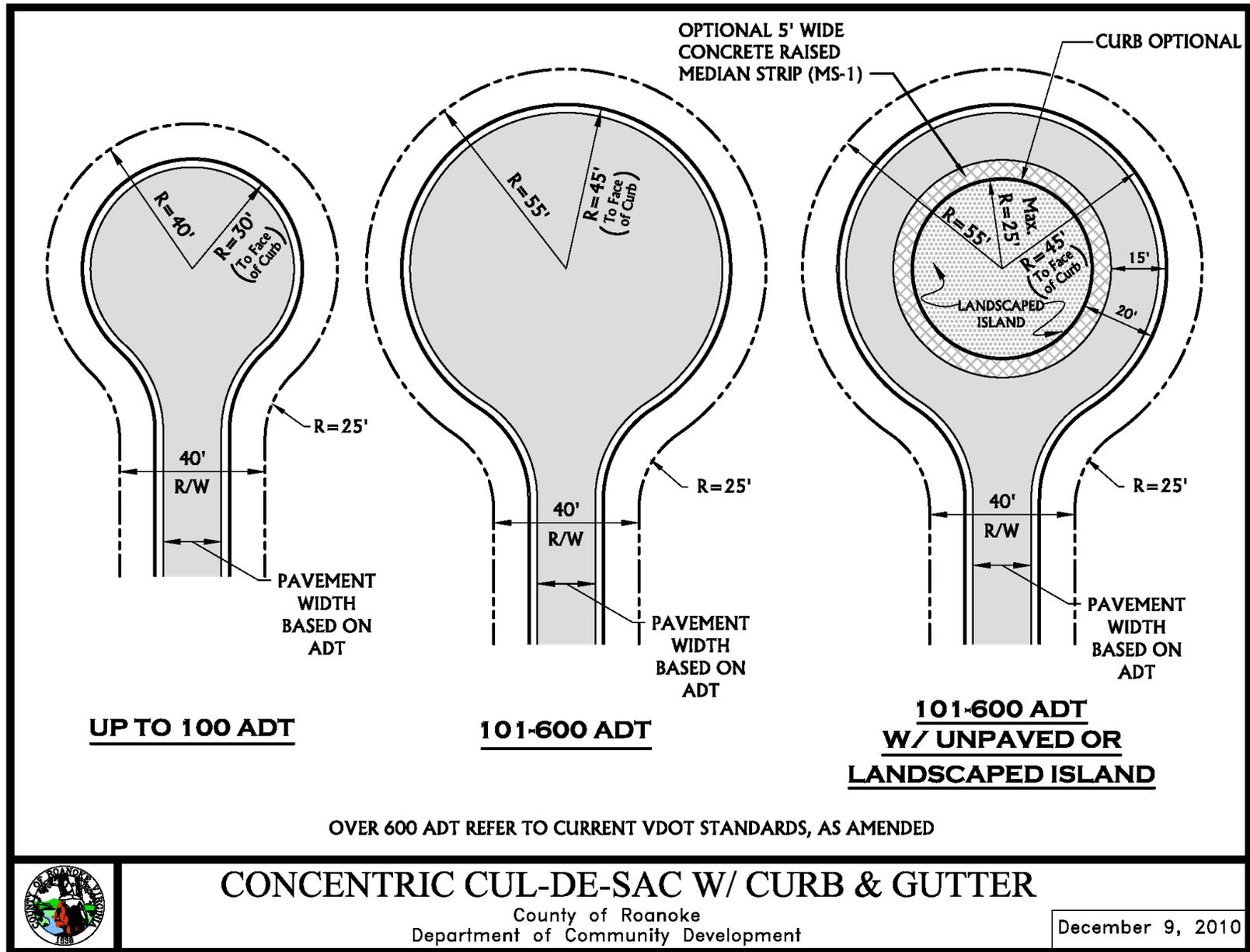


Figure 3.8-5 Shoulder and Ditch Offset Bulb Cul-de-Sacs

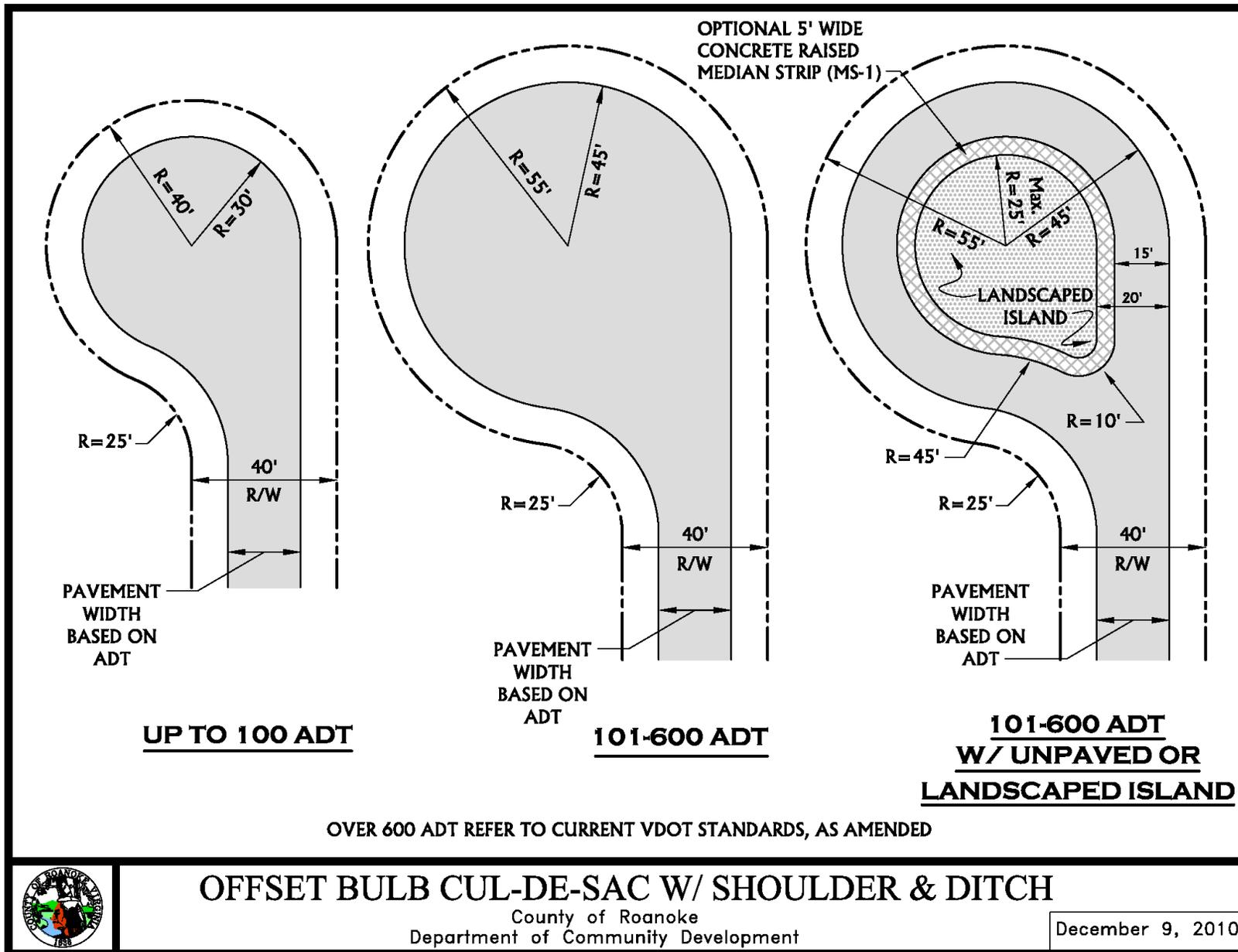


Figure 3.8-6 Curb and Gutter Offset Bulb Cul-de-Sacs

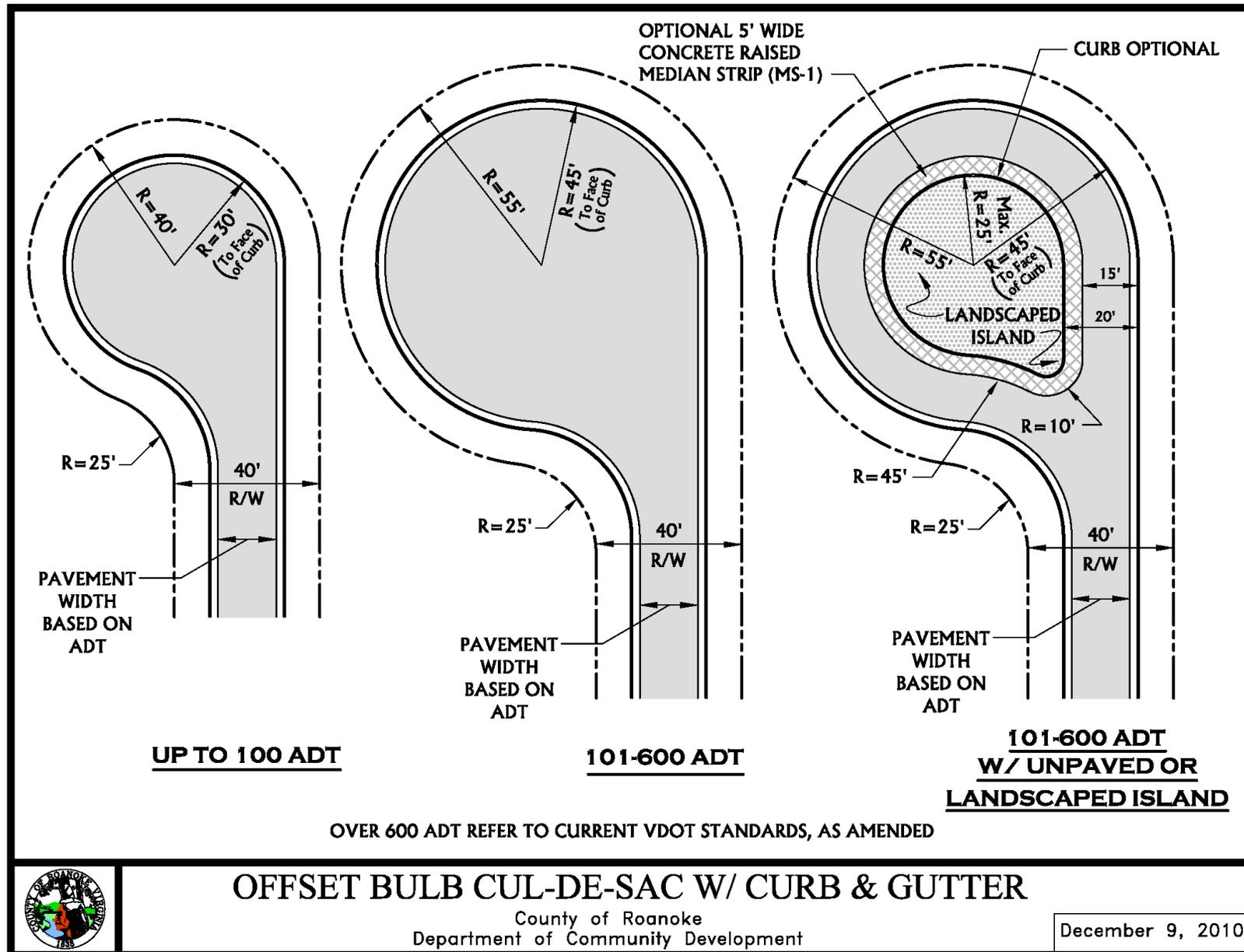
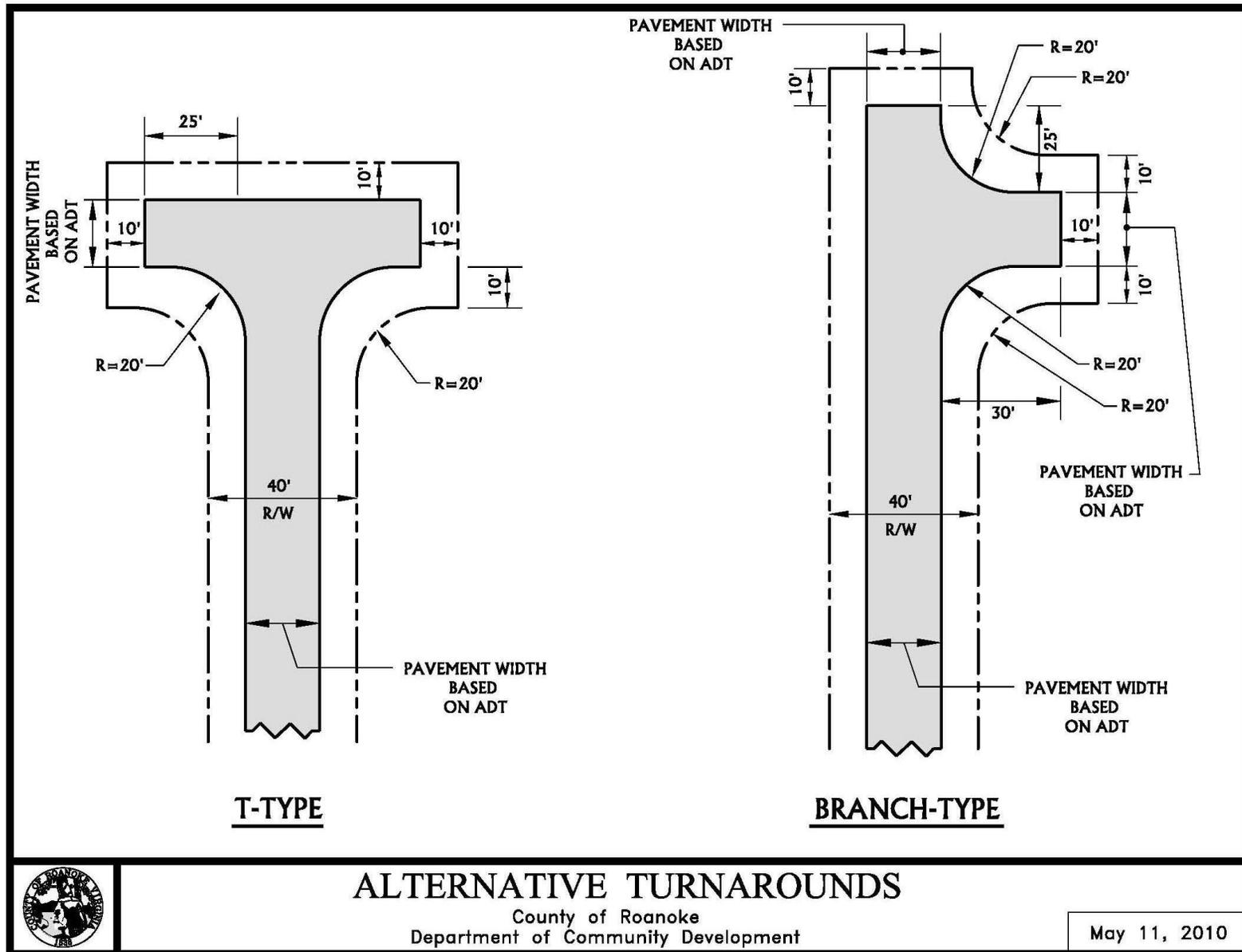


Figure 3.8-7 Alternative Turnarounds



5. Design Elements:

- a. Alleys. Alleys shall be owned and maintained by the Homeowners' Association, and notes to this effect shall be indicated on the final plat.
 - i. One-way alley^{cc}:
 - (A) Minimum Width: 12 feet wide paved width
 - (B) Minimum Right-of-Way Width: 20 feet wide^{dd}
 - ii. Two-way alley:
 - (A) Minimum Width: 16 feet wide paved width
 - (B) Minimum Right-of-Way Width: 24 feet wide
- b. Bridge and Culvert Design Criteria. Current VDOT standards^{ee}, as amended.
- c. Clear Zone. Current VDOT standards^{ff}, as amended.
- d. Compaction. Current VDOT standards, as amended.
- e. Curb and Gutter Design. Current VDOT standards, as amended. Use CG-6, CG-7 or roll-top curb.

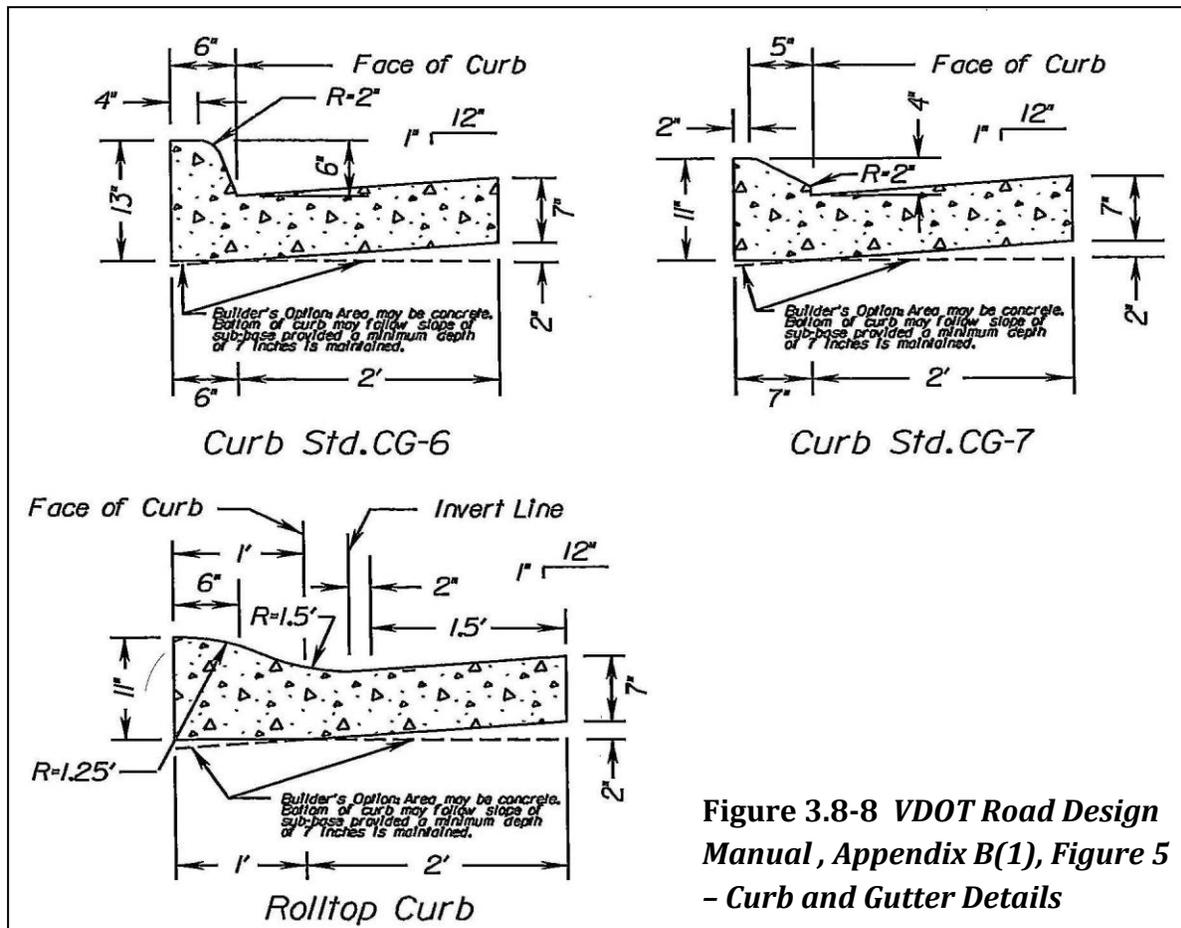
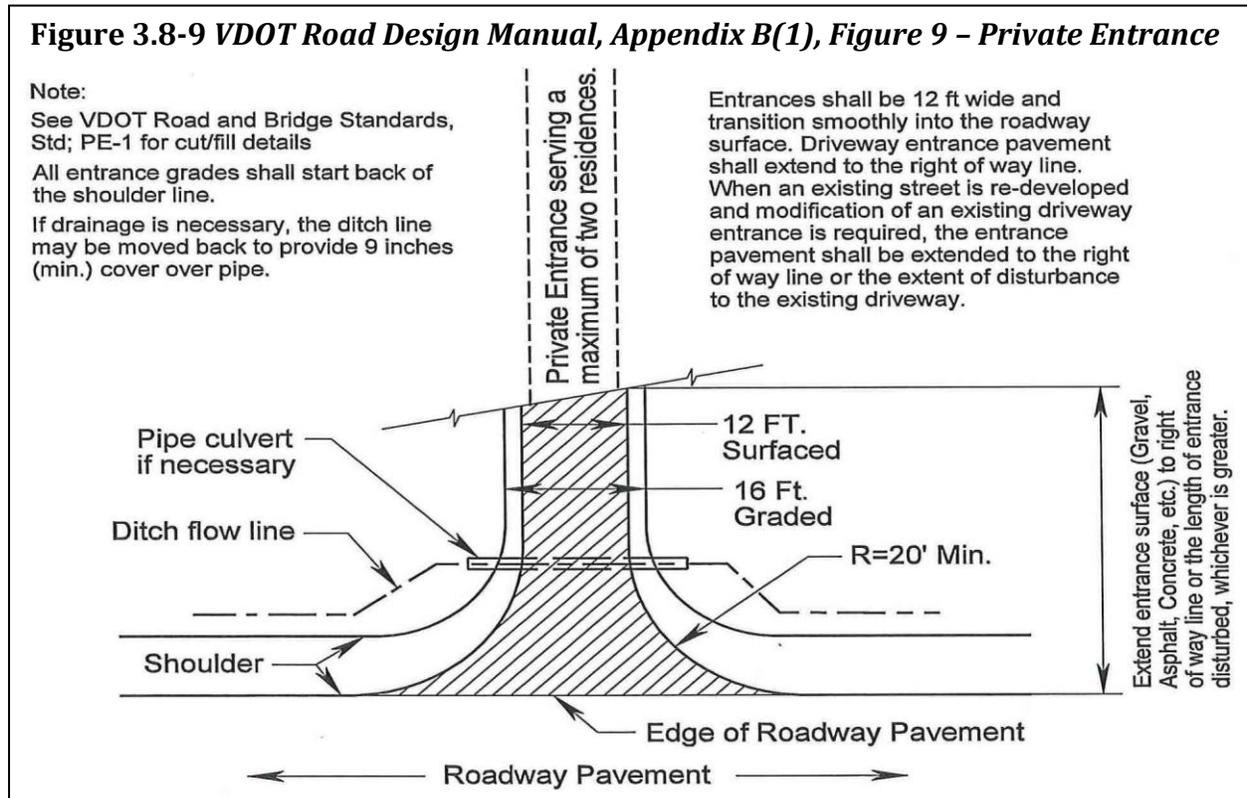


Figure 3.8-8 VDOT Road Design Manual, Appendix B(1), Figure 5 - Curb and Gutter Details

- i. Curb and gutter may be precast of Class A4 hydraulic cement concrete or cast in place using Class A3 hydraulic cement concrete.^{gg}
 - ii. When used with stabilized, open-graded drainage layers, the bottom of the curb and gutter shall be constructed parallel to the slope of the sub-base courses and to the depth of the pavement but not less than the thickness shown.^{hh}
- f. Drainage. The crown, or cross-slope, of the road's surface shall be 2 percent (1/4 inch to 1 foot) in tangent sections to convey run-off to the shoulders and ditches. These ditches should accommodate the design runoff in a manner that assures the safety of motorists and minimizes future maintenance, damage to adjacent properties, and adverse environmental, or aesthetic effects. Refer to current VDOT Road Design Manualⁱⁱ and VDOT Drainage Manual standards, as amended, for additional standards.
- g. Driveways^{jj}. In the interest of assuring adequate, convenient, and safe access to private roads, driveway landings shall not exceed ten percent

for a length of 30 feet^{kk}, measuring from the private road edge of pavement. At all driveway entrances, standard entrance gutter (Std. CG-9B or CG-9D) shall be used with Standard CG-6 or CG-7 curb and gutter^{ll}. See the graphic below for additional detail.



h. Grade.

- i. To allow for fire and rescue access the maximum grade shall comply with current VDOT standards, as amended^{mmm} at private driveway entrances and at fire hydrant locations.
- ii. At all other locations the maximum grade shall not exceed 17 percent unless a Design Exception is approved.
- iii. For locations other than at driveway entrances and at fire hydrant locations, a Design Exception request may be submitted to the Director of Community Development to increase the maximum grade for a certain length of private road only if one or more of the following circumstances are present:
 1. The length of road fronts $\frac{1}{2}$ acre lots or larger;
 2. The length of road is 150 feet or shorter;
 3. The length of road has a 150-foot tangent section;

4. Environmental constraints such as wetlands, FEMA floodways , jurisdictional waters or County-designated floodways are located in the immediate vicinity and will not be impacted because of the Design Exception; or
5. All dwelling units at and beyond the limit of the Design Exception are sprinkled.

The Director of Community Development in consultation with the Fire and Rescue Department shall make the final decision regarding the Design Exception.

Additional information that may be requested to assist in the final decision could include an alternative route to the Design Exception request to show that the Design Exception route presents fewer negative impacts than the alternative route.

- i. Green Shoulders. Current AASHTO standards, as amended.
- j. Guardrail. Current VDOT standards^{mn}, as amended.
- k. Horizontal and Vertical Controls. Current AASHTO standards, as amended (see charts below). All private roads shall be designed with a normal crown section; however, private roads measuring a maximum of 100 feet long with a maximum superelevation of 8 percent and serving no more than three dwelling units may be designed without a normal crown section.

Chart 3.8-3 Design Controls for Stopping Sight Distance and for Crest Vertical Curves			
Design Speed (mph)	Stopping Sight Distance (ft)	Rate of Vertical Curvature, K^a	
		Calculated	Design
20	115	6.1	7
25	155	11.1	12
30	200	18.5	19

Rate of vertical curvature, K , is the length of curve per percent algebraic difference in intersecting grades (A). $K = L/A$
Based on the 2004 AASHTO Green Book^{oo}

Chart 3.8-4 Design Controls for Sag Vertical Curves			
Design Speed (mph)	Stopping Sight Distance (ft)	Rate of Vertical Curvature, K^a	
		Calculated	Design
20	115	16.5	17
25	155	25.5	26
30	200	36.4	37

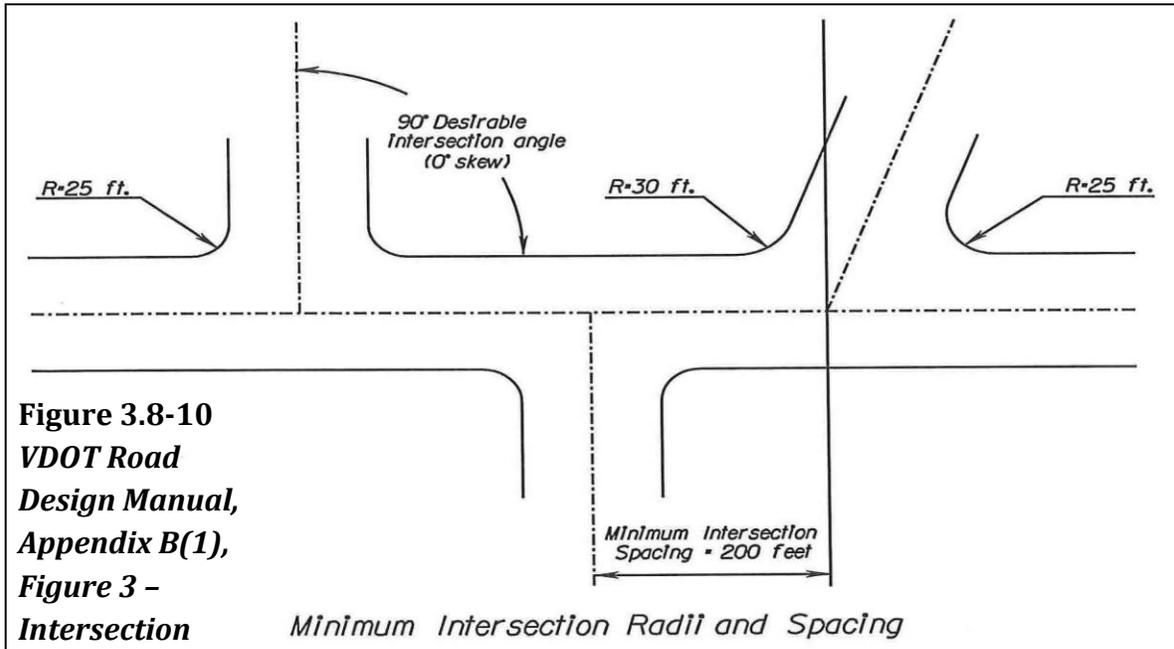
Rate of vertical curvature, K , is the length of curve (m) per percent algebraic difference intersecting grades (A). $K = L/A$
Based on the 2004 AASHTO Green Book^{pp}

Chart 3.8-5 Minimum Radii for Low-Speed Urban Streets			
Design Speed (mph)	20 mph	25 mph	30 mph
Radius (ft)	107	198	333

Based on the 2004 AASHTO Green Book^{qq}

- i. Intersections^{rr} (Excluding Alley Intersections)
 - i. Cross Road Grade.^{ss} The maximum difference between the pavement cross slope and the approach road grade shall not exceed 8 percent at stop intersections or 4 percent at continuous-movement intersections. (Current VDOT Road Design Manual and Subdivision Street Design Guide as amended) A landing having a minimum length of 50 feet and a maximum vertical grade of 5 percent shall be provided at each intersection.
 - ii. Angles. Streets should intersect at right angles; however, intersecting angles between 60 and 90 degrees are permitted. (Current VDOT Subdivision Street Design Guide, as amended)
 - iii. Spacing. Offset intersections are not allowed. Intersections or intersecting streets on the same side or opposite side shall be spaced at a minimum of 200 feet and this distance shall be adjusted upward based on upstream and downstream intersection turning movements. (Based on current VDOT Subdivision Street Design Guide, as amended)
 - iv. Minimum Radius. For skew intersections the radius shall not be less than 25 feet for the acute angle and 30 feet for the obtuse angle of the intersection street. (Current VDOT Subdivision Street Design Guide, as amended)
 - v. Visibility. At intersections, a minimum clear sight triangle shall be maintained as illustrated in the Intersection Design graphic below.

It shall be the responsibility of the developer/Homeowners' Association to maintain a clear sight triangle at all times.



- m. Lighting^{tt}. The installation, maintenance and operating expenses of lighting shall be provided by and at the sole expense of the developer or Homeowners' Association.
- n. One-Way, One-Lane Streets. One-way streets shall meet the dimensional requirements below and shall have two access points. Horizontal and vertical curvature shall meet the requirements stated above in Section 5k, Horizontal and Vertical Controls. Parking shall not be permitted along one-way, one-lane streets.

Chart 3.8-6 One-Way, One-Lane Street Standards			
Projected Traffic Volume (ADT)[^]	Shoulder and Ditch		Curb and Gutter
	Travelway Width (pavement only)	Roadway Width (including shoulders)	Pavement Width
Up to 600	12	16	12

Based on the 2004 AASHTO Green Book^{uu}

[^] To find the Average Daily Trip Generation (ADT) for a proposed land use, refer to the Institute of Transportation Engineers (ITE) Manual, as amended.

- o. Parking. Parking is not recommended along road sections with grades greater than 15 percent. In any location where parking is prohibited, "No Parking" signs shall be installed. Off-street parking spaces are permitted

in the private road right-of-way to provide overflow and guest parking. To allow access for solid waste collection and other delivery vehicles, parking shall not be permitted in cul-de-sacs with landscaped islands.

- p. Pavement Design. Current VDOT standards, as amended. All private roads shall be designed with a normal crown section, except as otherwise noted.
- q. Pedestrian Shelf. Where curb and gutter is used, a ¼ inch per foot (two percent) graded area, a minimum three feet in width, shall be provided behind the back of the curb^{vv} to transition from steeper adjacent grades. The pedestrian shelf is intended for pedestrian use and may include sidewalks and other related pedestrian amenities.
- r. Plat Covenant Language. Add the following note to each page of the plat of subdivision:

"The road serving this lot is private and its maintenance, including snow removal, is not a public responsibility. It shall not be eligible for acceptance into the state secondary system for maintenance until such time as it is constructed and otherwise complies with all requirements of the Virginia Department of Transportation for the addition of subdivision streets current at the time of such request. Any costs required to cause this street to become eligible for addition into the state system shall be provided with funds other than those administered by the Virginia Department of Transportation or Roanoke County."

- s. Right-of-Way. Minimum 30 foot width required. See current VDOT standards^{ww}, as amended, for additional information.
- t. Sight Distance to include Stopping Sight Distance, Intersection Sight Distance and Sight Distance Triangles (see AASHTO tables and VDOT graphic below).

Chart 3.8-7 Stopping Sight Distance on Grades						
Design Speed (mph)	Stopping Sight Distance (ft)					
	Downgrades			Upgrades		
	3%	6%	9%	3%	6%	9%
20	116	120	126	109	107	104
25	158	165	173	147	143	140
30	205	215	227	200	184	179

Based on the 2004 AASHTO Green Book^{xx}

Chart 3.8-8 Design Controls for Stopping Sight Distance and for Crest and Sag Vertical Curves

Initial Speed (mph)	Design stopping sight distance (ft)	Rate of vertical curvature, K^a (ft/%)	
		Crest	Sag
20	115	7	17
25	155	12	26
30	200	19	37

Rate of vertical curvature, K , is the length of curve per percent algebraic difference in the intersecting grades (i.e., $K = L/A$)

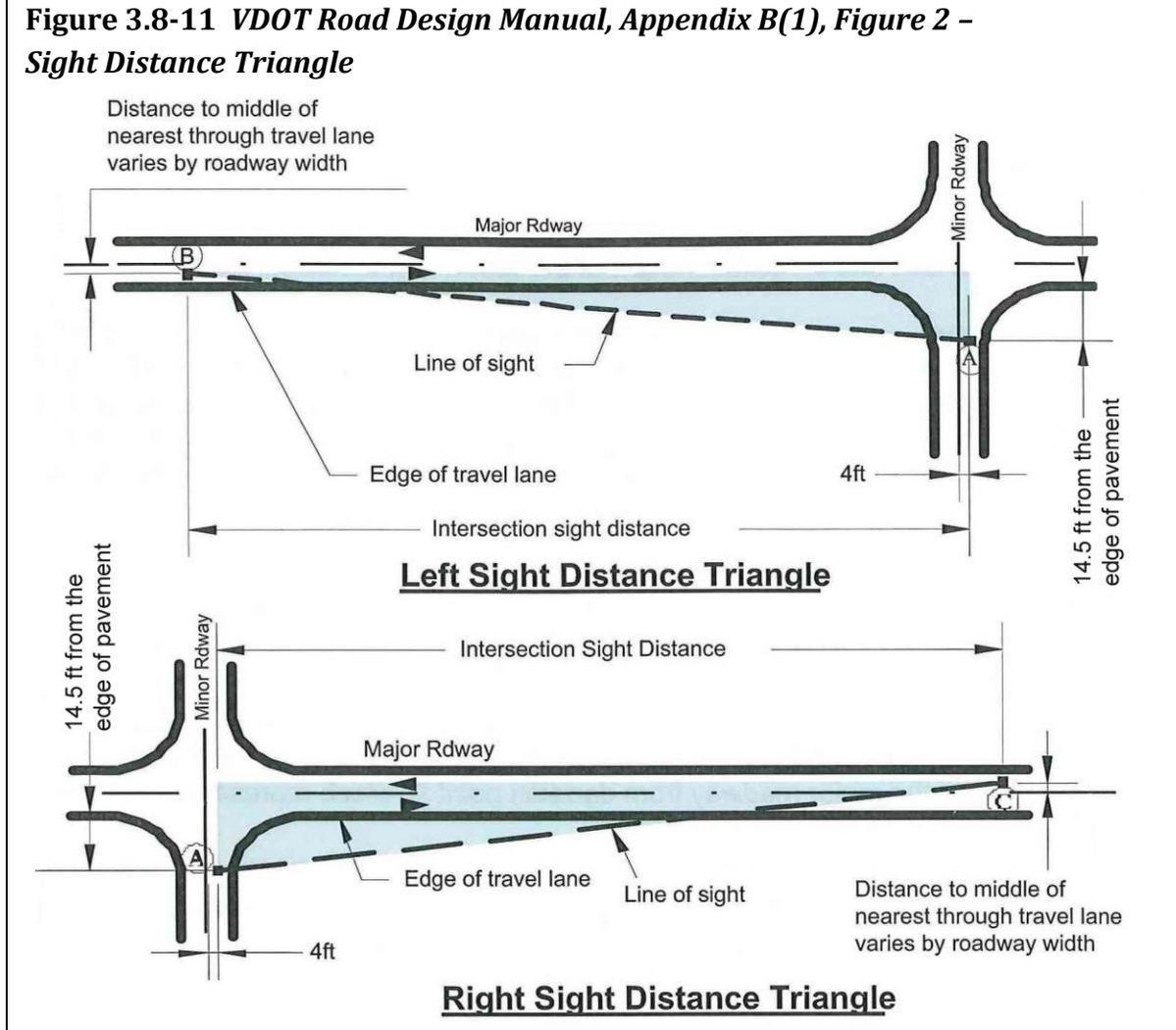
Based on the 2004 AASHTO Green Book^{yy}

Chart 3.8-9 Design Intersection Sight Distance - Case B1 - Left Turn from Stop

Design Speed (mph)	Stopping Sight Distance (ft)	Intersection Sight Distance for Passenger Cars	
		Calculated (ft)	Design (ft)
20	115	220.5	225
25	155	275.6	280
30	200	330.8	335

Note: Intersection sight distance shown is for a stopped passenger car to turn left onto a two-lane highway with no median and grades 3 percent or less. For other conditions, the time gap must be adjusted and required sight distance recalculated.

Based on the 2004 AASHTO Green Book^{zz}



- u. Shared Driveways. Shared driveways shall be permitted to serve no more than two houses. Shared driveways shall be created using access easements measuring 20 feet in width. Access easements shall be shown and noted on the Final Plat.
- v. Sidewalks. Sidewalks are encouraged to be located along private roads to encourage residents and their guests to walk in a designated pedestrian area separated from automobiles. Sidewalks shall be permitted within the right-of-way or within a public access easement and shall be maintained by the Homeowners' Association. Public access easements shall be shown and noted on the Final Plat. See Section 3.4, Sidewalks, for additional requirements.
- w. Speed Control/Traffic Calming Design Features. Speed control design features such as speed bumps, speed humps, etc., shall not be installed

unless approved by Roanoke County Community Development with input from the staff of County Schools, County General Services, and Fire and Rescue Departments.

- x. Standard Notes. Include a notation on the construction plans identifying the proposed private roads.
- y. Stormwater Management Facilities. Entry to privately owned and maintained stormwater management facilities and accesses shall be provided per the latest County of Roanoke Stormwater Management Design Manual. An easement shall be provided to Roanoke County for access and maintenance of a stormwater management facility. Such easements shall be noted on the plat. See Section (D)1. Drainage Easements, for additional standards.
- z. Traffic Control Devices and Signage. Each private road shall be identified with a street name sign at each intersection which shall be white with green lettering, per Roanoke County standards. Provide stop signs at entrance and interior intersections. Comply with the MUTCD Manual, as amended. Traffic signs and street name signs do not require sign permits. For all other signs, refer to Zoning Ordinance Section 30-93, Signs, to determine the need for a Sign Permit. Additional regulations:
 - i. Installation and Maintenance: The developer shall be responsible for purchasing, installing and maintaining all signs. When the private road is turned over to the Homeowners' Association it shall then be the responsibility of the Homeowners' Association to maintain all signs.
 - ii. Enforcement: The Roanoke County Police Department is unable to enforce traffic regulations on private roads. Parking enforcement shall be the responsibility of the owner of the private road or the Homeowners' Association.
 - iii. Maintenance of Traffic through Construction Areas: Refer to the MUTCD Manual, as amended.
- aa. Trip Generation/Average Daily Trips (ADT). Refer to the Institute of Transportation Engineers (ITE) *Trip Generation* manual, as amended.
- bb. Vertical Clearance Height. Private roads through forested areas or under other overhead obstructions must maintain proper clearance heights above the traveled way to allow passage of emergency vehicles. Tree

branches must be trimmed and maintained to obtain a minimum overhead clearance of 14 feet.

(D) Easements

1. *Drainage Easements:*

- a. The width and location of drainage and stormwater pond facility easements shall comply with the Stormwater Management Ordinance and Stormwater Design Manual, as amended.
- b. Private drainage easements shall be platted and dedicated to the homeowners' association for maintenance and notes to this effect shall be indicated on the final plat.
- c. Public drainage easements shall be platted and dedicated for public use.

2. *Sight Distance Easements:* Width and location to be determined by VDOT for public and private road intersections. For intersections of two or more private roads, dedicated right-of-way may be needed to preserve the line-of-sight. A sight distance easement may be an alternative to dedicated right-of-way.

3. *Water and Sewer Easements:* Width and location to be determined by the Western Virginia Water Authority or the Town of Vinton Department of Public Works depending upon the service provider.

4. *Public/Private Utility Easements:* Width and location to be determined by the appropriate utility company(ies)

(E) Public Services

1. *School Bus Service:* The private road standards generally meet Roanoke County Public Schools standards for school bus service; however, Roanoke County School Administration staff reserve the right to discontinue or relocate service on private roads if school buses cannot safely pick up children, pending advance notice to the owner of the private road, due to the following situations:

- a. Cars are frequently parked in No Parking zones or in other locations where parking is not permitted, prohibiting the bus from passing or turning around;
- b. Snow has not been plowed adequately from private roads to allow school buses to safely navigate them on more than one occasion;
- c. Ongoing construction creates an unsafe condition for either the children or the bus;

- d. Other conditions which would create an unsafe condition for either the children or the bus; or
 - e. The Homeowners' Association requests that the bus be removed due to noise, lighting, road damage or other unforeseen reasons.
2. *Solid Waste:* To receive public solid waste collection, a Private Road Waiver shall be completed and signed prior to site plan/subdivision plan approval. If a Private Road Waiver is not completed, the homeowners and/or homeowners' association has the responsibility for addressing the collection of solid waste.
 3. *Fire and Rescue Service:* A representative of the Fire and Rescue Department shall review the design and location of all proposed private streets, and shall advise the applicant whether or not the proposed private streets meet the standards for emergency services.

(F) Process

1. *Plan Submittal Requirements:* Refer to the Roanoke County Land Development Procedures, as amended.
2. *Erosion and Sediment Control:* All land disturbing activities shall comply with the Roanoke County Erosion and Sediment Control Ordinance, as amended.
3. *Inspections:* A third-party inspector shall inspect private roads following the requirements below:
 - a. Developer must contract with a licensed inspection firm certified to perform inspections not related to or affiliated with the developer or contractor;
 - b. Inspection procedures, testing methodology, and frequency of inspections are completed in accordance with VDOT Materials Division's Manual of Instructions and the Virginia Department of Transportation Road and Bridge Specifications. Inspections include but are not limited to:
 - i. Completion of subgrade, prior to the placement of any ballast material;
 - ii. Completion of ballast, prior to the placement of any top course of material; and
 - iii. Completion of installation of road signs, installation of any appurtenant structures, and reseeding of disturbed area and slopes.

4. *Final Report and As-Built Drawings:* At the completion of the road construction a report including two copies of As-Built drawings shall be submitted to Roanoke County Community Development by the developer. Roanoke County shall provide one copy of the As-Built drawings to the Roanoke County Fire Marshal.
 - a. *Final Report:* The Final Report shall include all material receipts, dates of inspection, work performed, changes or repairs ordered, inspection steps completed, certification of the results of inspections referenced in (F)3b, above, and confirmation that the streets were built to the approved plans, specifications and pavement design. The Final Report shall be signed and stamped by a Virginia licensed Professional Engineer.
 - b. *As-built drawings:* Requirements for As-Built drawings are as follows:
 - i. Changes to water, sewer, storm sewer, road grade and alignments.
 - ii. Drainage improvements as required by the Roanoke County Stormwater Management Ordinance and the Stormwater Design Manual, as amended.
 - iii. Public water and public sewer improvements per the Town of Vinton, if applicable.
 - iv. Private water and private sewer improvements per the Virginia Department of Health.
 - v. If requested, slope verification for road sections designed with grades of 15 percent or greater.
 - vi. If requested, a centerline as-built or right-of-way staking for confirmation of the road location.
5. *Turnover to Homeowners' Association:* To ensure that the Homeowners' Association does not receive substandard private roads, include the following notation on the plans:

“Immediately prior to the turnover of the private roads to the Homeowners' Association, Roanoke County shall inspect the private roads and any defects shall be repaired by the responsible party before the turnover occurs.”
6. *Maintenance:* A Homeowners' Association is required to be established to be responsible for all private roads, to include maintenance and upkeep of the private roads. The HOA shall also enforce parking restrictions.^{aaa}

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Appendix A: Board of Supervisors Ordinances

Figure A-1 Board of Supervisors Ordinance 052609-23

AT A REGULAR MEETING OF THE BOARD OF SUPERVISORS OF ROANOKE COUNTY, VIRGINIA, HELD AT THE ROANOKE COUNTY ADMINISTRATION CENTER ON TUESDAY, MAY 26, 2009

ORDINANCE 052609-23 AUTHORIZING THE DEVELOPMENT AND ADOPTION OF A DESIGN HANDBOOK TO ASSIST IN THE IMPLEMENTATION OF VARIOUS FEATURES FOR CHAPTER 30 OF THE ROANOKE COUNTY CODE (ZONING ORDINANCE)

WHEREAS, the public necessity, convenience, general welfare and good zoning practice requires the amendment to Chapter 30 of the Roanoke County Code (Zoning Ordinance) by the adoption of a Design Handbook; and,

WHEREAS, this Design Handbook provides graphic illustrations and diagrams of various elements and features of the Zoning Ordinance, including site design, landscaping, screening and buffering, transportation, parking, and other features; and,

WHEREAS, the Planning Commission held a public hearing on this ordinance on April 7, 2009; and,

WHEREAS, the Board of Supervisors held a first reading on this ordinance on May 12, 2009, and a second reading and public hearing on May 26, 2009.

BE IT ORDAINED By the Board of Supervisors of Roanoke County, Virginia, as follows:

1. That there is hereby established a Design Handbook for the County of Roanoke Zoning Ordinance.
2. That the County of Roanoke will utilize the policy, criteria and information including specifications and standards of the County of Roanoke Design Handbook for the proper implementation of the requirements of the Zoning Ordinance. This document shall include illustrations and diagrams of acceptable elements and features, including the specific design criteria for various amenities, improvements and features.

3. That the County of Roanoke Design Handbook may be updated and revised from time to time, based on improvements in design, landscaping, engineering, science, monitoring and local maintenance experience. The Planning Commission may recommend and the Board of Supervisors shall authorize and approve any updates, supplements, or modifications to the County of Roanoke Design Handbook by Resolution.

4. That the elements, amenities, improvements and features that are designed and constructed in accordance with these design criteria will be presumed to meet the minimum zoning ordinance performance standards.

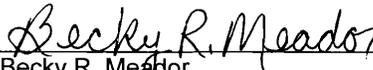
5. That this ordinance shall be in effect from and after the date of its adoption.

On motion of Supervisor Moore to adopt the ordinance, and carried by the following recorded vote:

AYES: Supervisors Moore, Church, Flora, McNamara, Altizer

NAYS: None

A COPY TESTE:


Becky R. Meador
Deputy Clerk to the Board

c: Circuit Court
Robert P. Doherty, Jr., Judge
James R. Swanson, Judge
Steven A. McGraw, Clerk
Bonnie Hager, Judicial Secretary
Norce Lowe, Secretary

Juvenile Domestic Relations District Court
Doris J. Johnson, Clerk (for distribution)

General District Court

Vincent A. Lilley, Judge

Theresa A. Childress, Clerk (for distribution)

Gerald Holt, Sheriff

Kevin Hutchins, Treasurer

Nancy Horn, Commissioner of Revenue

Paul Mahoney, County Attorney

Randy Leach, Commonwealth Attorney

Chief Magistrate Raymond Leven

Diana Rosapepe, Director of Library Services

Ray Lavinder, Police Chief

Richard Burch, Chief of Fire & Rescue

Roanoke Law Library, 315 Church Avenue, S.W., Rke 24016

Roanoke County Law Library, Singleton Osterhoudt

Roanoke County Code Book

B. Clayton Goodman, III, County Administrator

John M. Chambliss, Jr., Assistant County Administrator

Dan O'Donnell, Assistant County Administrator

Diane D. Hyatt, Chief Financial Officer

Arnold Covey, Director of Community Development

Tarek Moneir, Deputy Director of Development Services

Philip Thompson, Deputy Director of Planning

Rebecca Owens, Director of Finance

David Davis, Court Services

Elaine Carver, Chief Information Officer

Bill Greeves, Director of Information Technology

Anne Marie Green, Director of General Services

Pete Haislip, Director of Parks, Recreation & Tourism

William E. Driver Director of Real Estate Valuation

Brent Robertson, Director of Management & Budget

Figure A-2 Board of Supervisors Ordinance 032211-8

AT A REGULAR MEETING OF THE BOARD OF SUPERVISORS OF ROANOKE COUNTY, VIRGINIA, HELD AT THE ROANOKE COUNTY ADMINISTRATION CENTER ON TUESDAY, MARCH 22, 2011

ORDINANCE 032211-8 AMENDING THE ROANOKE COUNTY DESIGN HANDBOOK TO INCORPORATE DEVELOPMENT STANDARDS FOR PRIVATE ROADS, SIDEWALKS, SHARED USE PATHS, TRAILS AND BICYCLE ACCOMODATIONS

WHEREAS, on May 26, 2009, the Board of Supervisors adopted Ordinance 052609-23 which authorized the development and adoption of a Design Handbook to assist in the implementation of various features of the Roanoke County Zoning Ordinance; and

WHEREAS, on January 4, 2011, the Roanoke County Planning Commission held a public hearing on various amendments to the Design Handbook and on January 18, 2011, recommended said amendments to the Board of Supervisors for adoption; and

WHEREAS, on February 22, 2011, the Board of Supervisors held a work session on said amendments; and

WHEREAS, the amendments to the Design Handbook include private road standards, standards for sidewalks, shared use paths, private trails and bicycle accommodations, as well as formatting changes; and

WHEREAS, public necessity, convenience, general welfare and good zoning practice are valid public purposes for such recommendations by the Planning Commission and action by the Board of Supervisors; and

WHEREAS, the first reading of this ordinance was held on March 8, 2011, and the second reading and public hearing was held on March 22, 2011.

NOW THEREFORE BE IT ORDAINED by the Board of Supervisors of Roanoke County as follows:

1. That the Design Handbook is hereby amended and revised to include private road standards, standards for sidewalks, share use paths, private trails and bicycle accommodations as well as formatting changes.

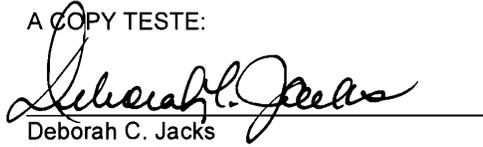
2. That the revised Roanoke County Design Handbook is attached and incorporated into this ordinance by reference and is effective from and after the date of this resolution.

On motion of Supervisor Altizer to adopt the ordinance, and carried by the following recorded vote:

AYES: Supervisors Moore, Altizer, Flora, Elswick, Church

NAYS: None

A COPY TESTE:



Deborah C. Jacks
Clerk to the Board of Supervisors

cc: Megan Cronise, Principal Planner
Arnold Covey, Director of Community Development

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Appendix B: Sidewalk, Shared Use Path, Trail and Private Road Standards References

Figure B-1 Sidewalk, Shared Use Path, Trail and Private Road Standards References

-
- ^a VDOT Road Design Manual, p. B(1)-31
 - ^b VDOT Road Design Manual, p. B(1)-27
 - ^c AASHTO Guide for the Planning, Design, and Operation of Pedestrian Facilities, p. 71
 - ^d VDOT Road Design Manual, p. B(1)-33; AASHTO Guide for the Development of Bicycle Facilities (1999) p. 35
 - ^e VDOT Road Design Manual, p. B(1)-33
 - ^f VDOT Road Design Manual, p. B(1)-33
 - ^g VDOT Road Design Manual, p. B(1)-35; AASHTO Guide for the Development of Bicycle Facilities (1999) p. 39
 - ^h VDOT Road Design Manual, p. B(1)-34
 - ⁱ VDOT Road Design Manual, p. B(1)-27
 - ^j Trail Solutions IMBA's Guide to Building Sweet Singletrack, p. 40
 - ^k Natural Surface Trails by Design Physical and Human Design Essentials of Sustainable, Enjoyable Trails, p. 13-20
 - ^l USDA Trail Construction and Maintenance Notebook, p. 24
 - ^m Trail Solutions IMBA's Guide to Building Sweet Singletrack, p. 137
 - ⁿ USDA Trail Construction and Maintenance Notebook, p. 44
 - ^o Trail Solutions IMBA's Guide to Building Sweet Singletrack, p. 137
 - ^p Trail Solutions IMBA's Guide to Building Sweet Singletrack, p. 64
 - ^q Trail Solutions IMBA's Guide to Building Sweet Singletrack, p. 66
 - ^r Trail Solutions IMBA's Guide to Building Sweet Singletrack, p. 63
 - ^s Trail Solutions IMBA's Guide to Building Sweet Singletrack, p. 56-69
 - ^t USDA Trail Construction and Maintenance Notebook, p. 119
 - ^u VDOT Road Design Manual, p. A-57
 - ^v AASHTO Green Book, p. 384 (added 2 feet)
 - ^w AASHTO Design of Very Low-Volume Roads, p. 18 (added 2 feet)
 - ^x AASHTO Green Book, p. 384
 - ^y AASHTO Green Book, p. 384 (added 2 feet)
 - ^z Cul-de-sac dimensions per VDOT Road Design Manual, p. B(1)-24, B(1)-25
 - ^{aa} City of Manassas (VA) Road Standards and Brian Blevins at VDOT; based on previous VDOT Standards
 - ^{bb} VDOT Road and Bridge Standards, 2001, p. 202.02
 - ^{cc} VDOT Road Design Manual p. A-16
 - ^{dd} AASHTO Green Book, p. 396
 - ^{ee} VDOT Road Design Manual, p. B(1)-37
 - ^{ff} VDOT Road Design Manual, p. B(1)-41
 - ^{gg} VDOT Road Design Manual, p. B(1)-26
 - ^{hh} VDOT Road Design Manual, p. B(1)-26
 - ⁱⁱ VDOT Road Design Manual, p. B(1)-38
 - ^{jj} VDOT Road Design Manual, p. B(1)-30
 - ^{kk} 30 foot length per Roanoke County Engineer
 - ^{ll} VDOT Road Design Manual, p. B(1)-28
 - ^{mmm} VDOT Road Design Manual, p. B(1)7, B(1)8
 - ⁿⁿ VDOT Road Design Manual, p. B(1)-43
 - ^{oo} AASHTO Green Book, p. 272
 - ^{pp} AASHTO Green Book, p. 277
 - ^{qq} AASHTO Green Book, p. 151
 - ^{rr} VDOT Road Design Manual, p. B(1)-21 and 22
 - ^{ss} VDOT Road Design Manual, p. C-4 and G-35
 - ^{tt} VDOT Road Design Manual, p. B(1)-53

^{uu} AASHTO Green Book, p. 396

^{vv} VDOT Road Design Manual, p. B(1)-27

^{ww} VDOT Road Design Manual, p. B(1)40

^{xx} AASHTO Green Book, p. 115

^{yy} AASHTO Green Book, p. 381

^{zz} AASHTO Green Book, p. 661; VDOT Road Design Manual, p. B(1)-7 and C-31

^{aaa} City of Corona (CA) Public Works Department Private Street Standards